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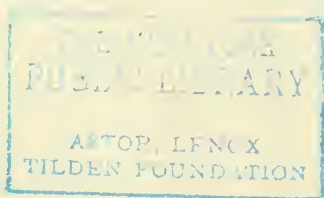
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AN EARLY REAPING MACHINE, 1840-50

From the painting by C. W. Jefferys

THE NEW INDUSTRIALISM

PART 1: THE AGE OF INVENTION

BY HOLLAND THOMPSON

PART 2: THE AGE OF BIG BUSINESS

BY BURTON J. HENDRICK



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PART I
THE AGE OF INVENTION
A CHRONICLE
OF MECHANICAL CONQUEST
BY
HOLLAND THOMPSON

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PREFATORY NOTE

THIS volume is not intended to be a complete record of inventive genius and mechanical progress in the United States. A bare catalogue of notable American inventions in the nineteenth century alone could not be compressed into these pages. Nor is it any part of the purpose of this book to trespass on the ground of the many mechanical works and encyclopedias which give technical descriptions and explain in detail the principle of every invention. All this book seeks to do is to outline the personalities of some of the outstanding American inventors and indicate the significance of their achievements.

Acknowledgments are due the Editor of the Series and to members of the staff of the Yale University Press—particularly, Miss Constance Lindsay Skinner, Mr. Arthur Edwin Krows, and Miss Frances Hart—without whose intelligent

assistance the book could not have been completed in time to take its place in the Series.

H. T.

COLLEGE OF THE CITY OF NEW YORK,
May 10, 1921.

CONTENTS

I.	BENJAMIN FRANKLIN AND HIS TIMES	Page	1
II.	ELI WHITNEY AND THE COTTON GIN	“	32
III.	STEAM IN CAPTIVITY	“	53
IV.	SPINDLE, LOOM, AND NEEDLE IN NEW ENGLAND	“	84
V.	THE AGRICULTURAL REVOLUTION	“	110
VI.	AGENTS OF COMMUNICATION	“	128
VII.	THE STORY OF RUBBER	“	157
VIII.	PIONEERS OF THE MACHINE SHOP	“	175
IX.	THE FATHERS OF ELECTRICITY	“	194
X.	THE CONQUEST OF THE AIR	“	220
	BIBLIOGRAPHICAL NOTE	“	247
	INDEX	“	255

THE AGE OF INVENTION

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CHAPTER I

BENJAMIN FRANKLIN AND HIS TIMES

ON Milk Street, in Boston, opposite the Old South Church, lived Josiah Franklin, a maker of soap and candles. He had come to Boston with his wife about the year 1682 from the parish of Ecton, Northamptonshire, England, where his family had lived on a small freehold for about three hundred years. His English wife had died, leaving him seven children, and he had married a colonial girl, Abiah Folger, whose father, Peter Folger, was a man of some note in early Massachusetts.

Josiah Franklin was fifty-one and his wife Abiah thirty-nine, when the first illustrious American inventor was born in their house on Milk Street, January 17, 1706. He was their eighth child and Josiah's tenth son and was baptized Benjamin.

What little we know of Benjamin's childhood is contained in his *Autobiography*, which the world has accepted as one of its best books and which was the first American book to be so accepted. In the crowded household, where thirteen children grew to manhood and womanhood, there were no luxuries. Benjamin's period of formal schooling was less than two years, though he could never remember the time when he could not read, and at the age of ten he was put to work in his father's shop.

Benjamin was restless and unhappy in the shop. He appeared to have no aptitude at all for the business of soap making. His parents debated whether they might not educate him for the ministry, and his father took him into various shops in Boston, where he might see artisans at work, in the hope that he would be attracted to some trade. But Benjamin saw nothing there that he wished to engage in. He was inclined to follow the sea, as one of his older brothers had done.

His fondness for books finally determined his career. His older brother James was a printer, and in those days a printer was a literary man as well as a mechanic. The editor of a newspaper was always a printer and often composed his articles as he set them in type; so "composing" came to mean

typesetting, and one who sets type is a compositor. Now James needed an apprentice. It happened then that young Benjamin, at the age of thirteen, was bound over by law to serve his brother.

James Franklin printed the *New England Courant*, the fourth newspaper to be established in the colonies. Benjamin soon began to write articles for this newspaper. Then when his brother was put in jail, because he had printed matter considered libelous, and forbidden to continue as the publisher, the newspaper appeared in Benjamin's name.

The young apprentice felt that his brother was unduly severe and, after serving for about two years, made up his mind to run away. Secretly he took passage on a sloop and in three days reached New York, there to find that the one printer in the town, William Bradford, could give him no work. Benjamin then set out for Philadelphia. By boat to Perth Amboy, on foot to Burlington, and then by boat to Philadelphia was the course of his journey, which consumed five days. On a Sunday morning in October, 1723, the tired, hungry boy landed upon the Market Street wharf, and at once set out to find food and explore America's metropolis.

Benjamin found employment with Samuel Keimer, an eccentric printer just beginning business,

and lodgings at the house of Read, whose daughter Deborah was later to become his wife. The intelligent young printer soon attracted the notice of Sir William Keith, Governor of Pennsylvania, who promised to set him up in business. First, however, he must go to London to buy a printing outfit. On the Governor's promise to send a letter of credit for his needs in London, Franklin set sail; but the Governor broke his word, and Franklin was obliged to remain in London nearly two years working at his trade. It was in London that he printed the first of his many pamphlets, an attack on revealed religion, called *A Dissertation on Liberty and Necessity, Pleasure and Pain*. Though he met some interesting persons, from each of whom he extracted, according to his custom, every particle of information possible, no future opened for him in London, and he accepted an offer to return to Philadelphia with employment as a clerk. But early in 1727 his employer died, and Benjamin went back to his trade, as printers always do. He found work again in Keimer's printing office. Here his mechanical ingenuity and general ability presently began to appear; he invented a method of casting type, made ink, and became, in fact, the real manager of the business.

The ability to make friends was one of Franklin's traits, and the number of his acquaintances grew rapidly, both in Pennsylvania and New Jersey. "I grew convinced," he naïvely says, "that *truth*, *sincerity*, and *integrity* in dealings between man and man were of the utmost importance to the felicity of life." Not long after his return from England he founded in Philadelphia the Junto, a society which at its regular meetings argued various questions and criticized the writings of the members. Through this society he enlarged his reputation as well as his education.

The father of an apprentice at Keimer's furnished the money to buy a printing outfit for his son and Franklin, but the son soon sold his share, and Benjamin Franklin, Printer, was fairly established in business at the age of twenty-four. The writing of an anonymous pamphlet on *The Nature and Necessity of a Paper Currency* called attention to the need of a further issue of paper money in Pennsylvania, and the author of the tract was rewarded with the contract to print the money, "a very profitable jobb, and a great help to me." Small favors were thankfully received. And: "I took care not only to be in *reality* industrious and frugal, but to avoid all appearances to the contrary.

I drest plainly; I was seen at no places of idle diversion." And, "to show that I was not above my business, I sometimes brought home the paper I purchas'd at the stores thro' the streets on a wheelbarrow."

The Universal Instructor in All Arts and Sciences and Pennsylvania Gazette: this was the high-sounding name of a newspaper which Franklin's old employer, Keimer, had started in Philadelphia. But bankruptcy shortly overtook Keimer, and Franklin took the newspaper with its ninety subscribers. The "Universal Instructor" feature of the paper consisted of a page or two weekly of *Chambers's Encyclopædia*. Franklin eliminated this feature and dropped the first part of the long name. *The Pennsylvania Gazette* in Franklin's hands soon became profitable. And it lives today in the fullness of abounding life, though under another name. "Founded A^D! 1728 by Benj. Franklin" is the proud legend of *The Saturday Evening Post*, which carries on, in our own times, the Franklin tradition.

The *Gazette* printed bits of local news, extracts from the London *Spectator*, jokes, verses, humorous attacks on Bradford's *Mercury*, a rival paper, moral essays by the editor, elaborate hoaxes, and pungent political or social criticism. Often the editor wrote

and printed letters to himself, either to emphasize some truth or to give him the opportunity to ridicule some folly in a reply to "Alice Addertongue," "Anthony Afterwit," or other mythical but none the less typical person.

If the countryman did not read a newspaper, or buy books, he was, at any rate, sure to own an almanac. So in 1732 Franklin brought out *Poor Richard's Almanack*. Three editions were sold within a few months. Year after year the sayings of Richard Saunders, the alleged publisher, and Bridget, his wife, creations of Franklin's fancy, were printed in the almanac. Years later the most striking of these sayings were collected and published. This work has been translated into as many as twenty languages and is still in circulation today.

Franklin kept a shop in connection with his printing office, where he sold a strange variety of goods: legal blanks, ink, pens, paper, books, maps, pictures, chocolate, coffee, cheese, codfish, soap, linseed oil, broadcloth, Godfrey's cordial, tea, spectacles, rattlesnake root, lottery tickets, and stoves — to mention only a few of the many articles he advertised. Deborah Read, who became his wife in 1730, looked after his house, tended shop, folded and stitched pamphlets,

bought rags, and helped him to live economically. "We kept no idle servants," says Franklin, "our table was plain and simple, our furniture of the cheapest. For instance, my breakfast was a long time bread and milk (no tea), and I ate it out of a twopenny earthen porringer with a pewter spoon."

With all this frugality, Franklin was not a miser; he abhorred the waste of money, not the proper use. His wealth increased rapidly. "I experienced too," he says, "the truth of the observation, '*that after getting the first hundred pound, it is more easy to get the second,*' money itself being of a prolific nature." He gave much unpaid public service and subscribed generously to public purposes; yet he was able, at the early age of forty-two, to turn over his printing office to one of his journeymen, and to retire from active business, intending to devote himself thereafter to such public employment as should come his way, to philosophical or scientific studies, and to amusements.

From boyhood Franklin had been interested in natural phenomena. His *Journal of a Voyage from London to Philadelphia*, written at sea as he returned from his first stay in London, shows unusual powers of exact observation for a youth of twenty. Many of the questions he propounded to

the Junto had a scientific bearing. He made an original and important invention in 1742, the "Pennsylvania fireplace," which, under the name of the Franklin stove, is in common use to this day, and which brought to the ill-made houses of the time increased comfort and a great saving of fuel. But it brought Franklin no pecuniary reward, for he never deigned to patent any of his inventions.

His active, inquiring mind played upon hundreds of questions in a dozen different branches of science. He studied smoky chimneys; he invented bifocal spectacles; he studied the effect of oil upon ruffled water; he identified the "dry bellyache" as lead poisoning; he preached ventilation in the days when windows were closed tight at night, and upon the sick at all times; he investigated fertilizers in agriculture. Many of his suggestions have since borne fruit, and his observations show that he foresaw some of the great developments of the nineteenth century.

His fame in science rests chiefly upon his discoveries in electricity. On a visit to Boston in 1746 he saw some electrical experiments and at once became deeply interested. Peter Collinson of London, a Fellow of the Royal Society, who had made several gifts to the Philadelphia Library, sent

over some of the crude electrical apparatus of the day, which Franklin used, as well as some contrivances he had purchased in Boston. He says in a letter to Collinson: "For my own part, I never was before engaged in any study that so engrossed my attention and my time as this has lately done."

Franklin's letters to Collinson tell of his first experiments and speculations as to the nature of electricity. Experiments made by a little group of friends showed the effect of pointed bodies in drawing off electricity. He decided that electricity was not the result of friction, but that the mysterious force was diffused through most substances, and that nature is always alert to restore its equilibrium. He developed the theory of positive and negative electricity, or plus and minus electrification. The same letter tells of some of the tricks which the little group of experimenters were accustomed to play upon their wondering neighbors. They set alcohol on fire, relighted candles just blown out, produced mimic flashes of lightning, gave shocks on touching or kissing, and caused an artificial spider to move mysteriously.

Franklin carried on experiments with the Leyden jar, made an electrical battery, killed a fowl and roasted it upon a spit turned by electricity, sent a

current through water and found it still able to ignite alcohol, ignited gunpowder, and charged glasses of wine so that the drinkers received shocks. More important, perhaps, he began to develop the theory of the identity of lightning and electricity, and the possibility of protecting buildings by iron rods. By means of an iron rod he brought down electricity into his house, where he studied its effect upon bells and concluded that clouds were generally negatively electrified. In June, 1752, he performed the famous experiment with the kite, drawing down electricity from the clouds and charging a Leyden jar from the key at the end of the string.

Franklin's letters to Collinson were read before the Royal Society but were unnoticed. Collinson gathered them together, and they were published in a pamphlet which attracted wide attention. Translated into French, they created great excitement, and Franklin's conclusions were generally accepted by the scientific men of Europe. The Royal Society, tardily awakened, elected Franklin a member and in 1753 awarded him the Copley medal with a complimentary address.¹

¹ It may be useful to mention some of the scientific facts and mechanical principles which were known to Europeans at this

If Franklin's desire to continue his scientific researches had been gratified, it is possible that he might have discovered some of the secrets for which the world waited until Edison and his contemporaries revealed them more than a century later. Franklin's scientific reputation has grown with the years, and some of his views seem in perfect accord with the latest developments in electricity. But he was not to be permitted to continue his experiments. He had shown his ability to manage men and was to be called to a wider field.

Franklin's influence among his fellow citizens in

time. More than one learned essay has been written to prove the mechanical indebtedness of the modern world to the ancient, particularly to the works of those mechanically minded Greeks: Archimedes, Aristotle, Ctesibius, and Hero of Alexandria. The Greeks employed the lever, the tackle, and the crane, the force-pump, and the suction-pump. They had discovered that steam could be mechanically applied, though they never made any practical use of steam. In common with other ancients they knew the principle of the mariner's compass. The Egyptians had the water-wheel and the rudimentary blast-furnace. The pendulum clock appears to have been an invention of the Middle Ages. The art of printing from movable type, beginning with Gutenberg about 1450, helped to further the Renaissance. The improved mariner's compass enabled Columbus to find the New World; gunpowder made possible its conquest. The compound microscope and the first practical telescope came from the spectacle makers of Middelburg, Holland, the former about 1590 and the latter about 1608. Harvey, an English physician, had discovered the circulation of the blood in 1628, and Newton, an English mathematician, the law of gravitation in 1685.

Philadelphia was very great. Always ostensibly keeping himself in the background and working through others, never contradicting, but carrying his point by shrewd questions which showed the folly of the contrary position, he continued to set on foot and carry out movements for the public good. He established the first circulating library in Philadelphia, and one of the first in the country, and an academy which grew into the University of Pennsylvania. He was instrumental in the foundation of a hospital. "I am often ask'd by those to whom I propose subscribing," said one of the doctors who had made fruitless attempts to raise money for the hospital, "Have you consulted Franklin upon this business?" Other public matters in which the busy printer was engaged were the paving and cleaning of the streets, better street lighting, the organization of a police force and of a fire company. A pamphlet which he published, *Plain Truth*, showing the helplessness of the colony against the French and Indians, led to the organization of a volunteer militia, and funds were raised for arms by a lottery. Franklin himself was elected colonel of the Philadelphia regiment, "but considering myself unfit, I declined the station and recommended Mr. Lawrence, a fine person and

man of influence, who was accordingly appointed." In spite of his militarism, Franklin retained the position which he held as Clerk of the Assembly, though the majority of the members were Quakers opposed to war on principle.

The American Philosophical Society owes its origin to Franklin. It was formally organized on his motion in 1743, but the society has accepted the organization of the Junto in 1727 as the actual date of its birth. From the beginning the society has had among its members many leading men of scientific attainments or tastes, not only of Philadelphia, but of the world. In 1769 the original society was consolidated with another of similar aims, and Franklin, who was the first secretary of the society, was elected president and served until his death. The first important undertaking was the successful observation of the transit of Venus in 1769, and many important scientific discoveries have since been made by its members and first given to the world at its meetings.

Franklin's appointment as one of the two Deputy Postmasters General of the colonies in 1753 enlarged his experience and his reputation. He visited nearly all the post offices in the colonies and introduced many improvements into the service.

In none of his positions did his transcendent business ability show to better advantage. He established new postal routes and shortened others. There were no good roads in the colonies, but his post riders made what then seemed wonderful speed. The bags were opened to newspapers, the carrying of which had previously been a private and unlawful perquisite of the riders. Previously there had been one mail a week in summer between New York and Philadelphia and one a month in winter. The service was increased to three a week in summer and one in winter.

The main post road ran from northern New England to Savannah, closely hugging the seacoast for the greater part of the way. Some of the mile-stones set by Franklin to enable the postmasters to compute the postage, which was fixed according to distance, are still standing. Crossroads connected some of the larger communities away from the seacoast with the main road, but when Franklin died, after serving also as Postmaster General of the United States, there were only seventy-five post offices in the entire country.

Franklin took a hand in the final struggle between France and England in America. On the eve of the conflict, in 1754, commissioners from the

several colonies were ordered to convene at Albany for a conference with the Six Nations of the Iroquois, and Franklin was one of the deputies from Pennsylvania. On his way to Albany he "projected and drew a plan for the union of all the colonies under one government so far as might be necessary for defense and other important general purposes." This statesmanlike "Albany Plan of Union," however, came to nothing. "Its fate was singular," says Franklin; "the assemblies did not adopt it, as they all thought there was too much *prerogative* in it and in England it was judg'd to have too much of the *democratic*."

How to raise funds for defense was always a grave problem in the colonies, for the assemblies controlled the purse-strings and released them with a grudging hand. In face of the French menace, this was Governor Shirley's problem in Massachusetts, Governor Dinwiddie's in Virginia, and Franklin's in the Quaker and proprietary province of Pennsylvania. Franklin opposed Shirley's suggestion of a general tax to be levied on the colonies by Parliament, on the ground of no taxation without representation, but used all his arts to bring the Quaker Assembly to vote money for defense, and succeeded. When General Braddock arrived

in Virginia Franklin was sent by the Assembly to confer with him in the hope of allaying any prejudice against Quakers that the general might have conceived. If that blustering and dull-witted soldier had any such prejudice, it melted away when the envoy of the Quakers promised to procure wagons for the army. The story of Braddock's disaster does not belong here, but Franklin formed a shrewd estimate of the man which proved accurate. His account of Braddock's opinion of the colonial militia is given in a sentence: "He smil'd at my ignorance, and reply'd, 'These savages may, indeed, be a formidable enemy to your raw American militia, but upon the King's regular and disciplin'd troops, sir, it is impossible they should make any impression.'" After Braddock's defeat the Pennsylvania Assembly voted more money for defense, and the unmilitary Franklin was placed in command of the frontier with full power. He built forts, as he had planned, and incidentally learned much of the beliefs of a group of settlers in the back country, the "Unitas Fratrum," better known as the Moravians.

The death struggle between English and French in America served only to intensify a lesser conflict that was being waged between the Assembly and

the proprietors of Pennsylvania; and the Assembly determined to send Franklin to London to seek judgment against the proprietors and to request the King to take away from them the government of Pennsylvania. Franklin, accompanied by his son William, reached London in July, 1757, and from this time on his life was to be closely linked with Europe. He returned to America six years later and made a trip of sixteen hundred miles inspecting postal affairs, but in 1764 he was again sent to England to renew the petition for a royal government for Pennsylvania, which had not yet been granted. Presently that petition was made obsolete by the Stamp Act, and Franklin became the representative of the American colonies against King and Parliament.

Franklin did his best to avert the Revolution. He made many friends in England, wrote pamphlets and articles, told comical stories and fables where they might do some good, and constantly strove to enlighten the ruling class of England upon conditions and sentiment in the colonies. His examination before the House of Commons in February, 1766, marks perhaps the zenith of his intellectual powers. His wide knowledge, his wonderful poise, his ready wit, his marvelous gift

for clear and epigrammatic statement; were never exhibited to better advantage and no doubt hastened the repeal of the Stamp Act. Franklin remained in England nine years longer, but his efforts to reconcile the conflicting claims of Parliament and the colonies were of no avail, and early in 1775 he sailed for home.

Franklin's stay in America lasted only eighteen months, yet during that time he sat in the Continental Congress and as a member of the most important committees; submitted a plan for a union of the colonies; served as Postmaster General and as chairman of the Pennsylvania Committee of Safety; visited Washington at Cambridge; went to Montreal to do what he could for the cause of independence in Canada; presided over the convention which framed a constitution for Pennsylvania; was a member of the committee appointed to draft the Declaration of Independence and of the committee sent on the futile mission to New York to discuss terms of peace with Lord Howe.

In September, 1776, Franklin was appointed envoy to France and sailed soon afterwards. The envoys appointed to act with him proved a handicap rather than a help, and the great burden of a difficult and momentous mission was thus laid upon

an old man of seventy. But no other American could have taken his place. His reputation in France was already made, through his books and inventions and discoveries. To the corrupt and licentious court he was the personification of the age of simplicity, which it was the fashion to admire; to the learned, he was a sage; to the common man he was the apotheosis of all the virtues; to the rabble he was little less than a god. Great ladies sought his smiles; nobles treasured a kindly word; the shopkeeper hung his portrait on the wall; and the people drew aside in the streets that he might pass without annoyance. Through all this adulation Franklin passed serenely, if not unconsciously.

The French ministers were not at first willing to make a treaty of alliance, but under Franklin's influence they lent money to the struggling colonies. Congress sought to finance the war by the issue of paper currency and by borrowing rather than by taxation, and sent bill after bill to Franklin, who somehow managed to meet them by putting his pride in his pocket, and applying again and again to the French Government. He fitted out privateers and negotiated with the British concerning prisoners. At length he won from France

recognition of the United States and then the Treaty of Alliance.

Not until two years after the Peace of 1783 would Congress permit the veteran to come home. And when he did return in 1785 his people would not allow him to rest. At once he was elected President of the Council of Pennsylvania and twice reëlected in spite of his protests. He was sent to the Convention of 1787 which framed the Constitution of the United States. There he spoke seldom but always to the point, and the Constitution is the better for his suggestions. With pride he affixed his signature to that great instrument, as he had previously signed the Albany Plan of Union, the Declaration of Independence, and the Treaty of Paris.

Benjamin Franklin's work was done. He was now an old man of eighty-two summers and his feeble body was racked by a painful malady. Yet he kept his face towards the morning. About a hundred of his letters, written after this time, have been preserved. These letters show no retrospection, no looking backward. They never mention "the good old times." As long as he lived, Franklin looked forward. His interest in the mechanical arts and in scientific progress seems never to have

abated. He writes in October, 1787, to a friend in France, describing his experience with lightning conductors and referring to the work of David Rittenhouse, the celebrated astronomer of Philadelphia. On the 31st of May in the following year he is writing to the Reverend John Lathrop of Boston:

I have long been impressed with the same sentiments you so well express, of the growing felicity of mankind, from the improvement in philosophy, morals, politics, and even the conveniences of common living, and the invention of new and useful utensils and instruments; so that I have sometimes wished it had been my destiny to be born two or three centuries hence. For invention and improvement are prolific, and beget more of their kind. The present progress is rapid. Many of great importance, now unthought of, will, before that period, be produced.

Thus the old philosopher felt the thrill of dawn and knew that the day of great mechanical inventions was at hand. He had read the meaning of the puffing of the young steam engine of James Watt and he had heard of a marvelous series of British inventions for spinning and weaving. He saw that his own countrymen were astir, trying to substitute the power of steam for the strength of muscles and the fitful wind. John Fitch on the Delaware and

James Rumsey on the Potomac were already moving vessels by steam. John Stevens of New York and Hoboken had set up a machine shop that was to mean much to mechanical progress in America. Oliver Evans, a mechanical genius of Delaware, was dreaming of the application of high-pressure steam to both road and water carriages. Such manifestations, though still very faint, were to Franklin the signs of a new era.

And so, with vision undimmed, America's most famous citizen lived on until near the end of the first year of George Washington's administration. On April 17, 1790, his unconquerable spirit took its flight.

In that year, 1790, was taken the First Census of the United States. The new nation had a population of about four million people. It then included practically the present territory east of the Mississippi, except the Floridas, which belonged to Spain. But only a small part of this territory was occupied. Much of New York and Pennsylvania was savage wilderness. Only the seacoast of Maine was inhabited, and the eighty-two thousand inhabitants of Georgia hugged the Savannah River. Hardy pioneers had climbed the Alleghanies into

Kentucky and Tennessee, but the Northwest Territory — comprising Ohio, Michigan, Indiana, Illinois, and Wisconsin — was not enumerated at all, so scanty were its people, perhaps not more than four thousand.

Though the First Census did not classify the population by occupation it is certain that nine-tenths of the breadwinners worked more or less upon the soil. The remaining tenth were engaged in trade, transportation, manufacturing, fishing, and included also the professional men, doctors, lawyers, clergymen, teachers, and the like. In other words, nine out of ten of the population were engaged primarily in the production of food, an occupation which today engages less than three out of ten. This comparison, however, requires some qualification. The farmer and the farmer's wife and children performed many tasks which are now done in factories. The successful farmer on the frontier had to be a jack of many trades. Often he tanned leather and made shoes for his family and harness for his horses. He was carpenter, blacksmith, cobbler, and often boat-builder and fisherman as well. His wife made soap and candles, spun yarn and dyed it, wove cloth and made the clothes the family wore, to mention only

a few of the tasks of the women of the eighteenth century.

The organization of industry, however, was beginning. Here and there were small paper mills, glass factories — though many houses in the back country were without glass windows — potteries, and iron foundries and forges. Capitalists, in some places, had brought together a few handloom weavers to make cloth for sale, and the famous shoemakers of Massachusetts commonly worked in groups.

The mineral resources of the United States were practically unknown. The country seems to have produced iron enough for its simple needs, some coal, copper, lead, gold, silver, and sulphur. But we may say that mining was hardly practiced at all.

The fisheries and the shipyards were great sources of wealth, especially for New England. The cod fishers numbered several hundred vessels and the whalers about forty. Thousands of citizens living along the seashore and the rivers fished more or less to add to the local food supply. The deep-sea fishermen exported a part of their catch, dried and salted. Yankee vessels sailed to all ports of the world and carried the greater part of the

foreign commerce of the United States. Flour, tobacco, rice, wheat, corn, dried fish, potash, indigo, and staves were the principal exports. Great Britain was the best customer, with the French West Indies next, and then the British West Indies. The principal imports came from the same countries. Imports and exports practically balanced each other, at about twenty million dollars annually, or about five dollars a head. The great merchants owned ships and many of them, such as John Hancock of Boston, and Stephen Girard of Philadelphia, had grown very rich.

Inland transportation depended on horses and oxen or boats. There were few good roads, sometimes none at all save bridle paths and trails. The settlers along the river valleys used boats almost entirely. Stage-coaches made the journey from New York to Boston in four days in summer and in six in winter. Two days were required to go between New York and Philadelphia. Forty to fifty miles a day was the speed of the best coaches, provided always that they did not tumble into the ditch. In many parts of the country one must needs travel on horseback or on foot.

Even the wealthiest Americans of those days had few or none of the articles which we regard today

as necessities of life. The houses were provided with open fires — which, however cheerful, did not keep them warm — or else with Franklin's stoves. To strike a fire one must have the flint and tinder-box, for matches were unknown until about 1830. Candles made the darkness visible. There was neither plumbing nor running water. Food was cooked in the ashes or over an open fire.

The farmer's tools were no less crude than his wife's. His plough had been little improved since the days of Rameses. He sowed his wheat by hand, cut it with a sickle, flailed it out upon the floor, and laboriously winnowed away the chaff.

In that same year, 1790, came a great boon and encouragement to inventors, the first Federal Patent Act, passed by Congress on the 10th of April. Every State had its own separate patent laws or regulations, as an inheritance from colonial days, but the Fathers of the Constitution had wisely provided that this function of government should be exercised by the nation.¹ The Patent Act, however, was for a time unpopular, and some

¹ The Constitution (Article I, Section 8, Clause 8) empowers Congress: "To promote the Progress of Science and useful Arts. by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries."

States granted monopolies, particularly of transportation, until they were forbidden to do so by judicial decision.

The first Patent Act provided that an examining board, consisting of the Secretary of State, the Secretary of War, and the Attorney-General, or any two of them, might grant a patent for fourteen years, if they deemed the invention useful and important. The patent itself was to be engrossed and signed by the President, the Secretary of State, and the Attorney-General. And the cost was to be three dollars and seventy cents, plus the cost of copying the specifications at ten cents a sheet.

The first inventor to avail himself of the advantages of the new Patent Act was Samuel Hopkins of Vermont, who received a patent on the 31st of July for an improved method of "Making Pot and Pearl Ashes." The world knows nothing of this Samuel Hopkins, but the potash industry, which was evidently on his mind, was quite important in his day. Potash, that is, crude potassium carbonate, useful in making soap and in the manufacture of glass, was made by leaching wood ashes and boiling down the lye. To produce a ton of potash, the trees on an acre of ground would be

cut down and burned, the ashes leached, and the lye evaporated in great iron kettles. A ton of potash was worth about twenty-five dollars. Nothing could show more plainly the relative value of money and human labor in those early times.

Two more patents were issued during the year 1790. The second went to Joseph S. Sampson of Boston for a method of making candles, and the third to Oliver Evans, of whom we shall learn more presently, for an improvement in manufacturing flour and meal. The fourth patent was granted in 1791 to Francis Baily of Philadelphia for making punches for types. Next Aaron Putnam of Medford, Massachusetts, thought that he could improve methods of distilling, and John Stone of Concord, Massachusetts, offered a new method of driving piles for bridges. And a versatile inventor, Samuel Mulliken of Philadelphia, received four patents in one day for threshing grain, cutting and polishing marble, raising a nap on cloth, and breaking hemp.

Then came improvements in making nails, in making bedsteads, in the manufacture of boats, and for propelling boats by cattle. On August 26, 1791, James Rumsey, John Stevens, and John Fitch (all three will appear again in this narrative)

took out patents on means of propelling boats. On the same day Nathan Read received one on a process for distilling alcohol.

More than fifty patents were granted under the Patent Act of 1790, and mechanical devices were coming in so thick and fast that the department heads apparently found it inconvenient to hear applications. So the Act of 1790 was repealed. The second Patent Act (1793) provided that a patent should be granted as a matter of routine to any one who swore to the originality of his device and paid the sum of thirty dollars as a fee. No one except a citizen, however, could receive a patent. This act, with some amendments, remained in force until 1836, when the present Patent Office was organized with a rigorous and intricate system for examination of all claims in order to prevent interference. Protection of the property rights of inventors has been from the beginning of the nation a definite American policy, and to this policy may be ascribed innumerable inventions which have contributed to the greatness of American industry and multiplied the world's comforts and conveniences.

Under the second Patent Act came the most important invention yet offered, an invention

which was to affect generations then unborn. This was a machine for cleaning cotton and it was offered by a young Yankee schoolmaster, temporarily sojourning in the South.

CHAPTER II

ELI WHITNEY AND THE COTTON GIN

THE cotton industry is one of the most ancient. One or more of the many species of the cotton plant is indigenous to four continents, Asia, Africa, and the Americas, and the manufacture of the fiber into yarn and cloth seems to have developed independently in each of them. We find mention of cotton in India fifteen hundred years before Christ. The East Indians, with only the crudest machinery, spun yarn and wove cloth as diaphanous as the best appliances of the present day have been able to produce.

Alexander the Great introduced the "vegetable wool" into Europe. The fable of the "vegetable lamb of Tartary" persisted almost down to modern times. The Moors cultivated cotton in Spain on an extensive scale, but after their expulsion the industry languished. The East India Company imported cotton fabrics into England early in the

seventeenth century, and these fabrics made their way in spite of the bitter opposition of the woolen interests, which were at times strong enough to have the use of cotton cloth prohibited by law. But when the Manchester spinners took up the manufacture of cotton, the fight was won. The Manchester spinners, however, used linen for their warp threads, for without machinery they could not spin threads sufficiently strong from the short-fibered Indian cotton.

In the New World the Spanish explorers found cotton and cotton fabrics in use everywhere. Columbus, Cortés, Pizarro, Magellan, and others speak of the various uses to which the fiber was put, and admired the striped awnings and the colored mantles made by the natives. It seems probable that cotton was in use in the New World quite as early as in India.

The first English settlers in America found little or no cotton among the natives. But they soon began to import the fiber from the West Indies, whence came also the plant itself into the congenial soil and climate of the Southern colonies. During the colonial period, however, cotton never became the leading crop, hardly an important crop. Cotton could be grown profitably only where there

was an abundant supply of exceedingly cheap labor, and labor in America, white or black, was never and could never be as cheap as in India. American slaves could be much more profitably employed in the cultivation of rice and indigo.

Three varieties of the cotton plant were grown in the South. Two kinds of the black-seed or long-staple variety thrived in the sea-islands and along the coast from Delaware to Georgia, but only the hardier and more prolific green-seed or short-staple cotton could be raised inland. The labor of cultivating and harvesting cotton of any kind was very great. The fiber, growing in bolls resembling a walnut in size and shape, had to be taken by hand from every boll, as it has to be today, for no satisfactory cotton harvester has yet been invented. But in the case of the green-seed or upland cotton, the only kind which could ever be cultivated extensively in the South, there was another and more serious obstacle in the way, namely, the difficulty of separating the fiber from the seeds. No machine yet devised could perform this tedious and unprofitable task. For the black-seed or sea-island cotton, the *churka*, or roller gin, used in India from time immemorial, drawing the fiber slowly between a pair of rollers to push out the seeds, did the work

imperfectly, but this *churka* was entirely useless for the green-seed variety, the fiber of which clung closely to the seed and would yield only to human hands. The quickest and most skillful pair of hands could separate only a pound or two of lint from its three pounds of seeds in an ordinary working day. Usually the task was taken up at the end of the day, when the other work was done. The slaves sat round an overseer who shook the dozing and nudged the slow. It was also the regular task for a rainy day. It is not surprising, then, that cotton was scarce, that flax and wool in that day were the usual textiles, that in 1783 wool furnished about seventy-seven per cent, flax about eighteen per cent, and cotton only about five per cent of the clothing of the people of Europe and the United States.

That series of inventions designed for the manufacture of cloth, and destined to transform Great Britain, the whole world, in fact, was already completed in Franklin's time. Beginning with the flying shuttle of John Kay in 1738, followed by the spinning jenny of James Hargreaves in 1764, the water-frame of Richard Arkwright in 1769, and the mule of Samuel Crompton ten years later, machines were provided which could spin any

quantity of fiber likely to be offered. And when, in 1787, Edmund Cartwright, clergyman and poet, invented the self-acting loom to which power might be applied, the series was complete. These inventions, supplementing the steam engine of James Watt, made the Industrial Revolution. They destroyed the system of cottage manufactures in England and gave birth to the great textile establishments of today.

The mechanism for the production of cloth on a great scale was provided, if only the raw material could be found.

The romance of cotton begins on a New England farm. It was on a farm in the town (township) of Westboro, in Worcester County, Massachusetts, in the year 1765, that Eli Whitney, inventor of the cotton gin, was born. Eli's father was a man of substance and standing in the community, a mechanic as well as a farmer, who occupied his leisure in making articles for his neighbors. We are told that young Eli displayed a passion for tools almost as soon as he could walk, that he made a violin at the age of twelve and about the same time took his father's watch to pieces surreptitiously and succeeded in putting it together again so successfully as to escape detection. He was able

to make a table knife to match the others of a broken set. As a boy of fifteen or sixteen, during the War of Independence, he was supplying the neighborhood with hand-made nails and various other articles. Though he had not been a particularly apt pupil in the schools, he conceived the ambition of attending college; and so, after teaching several winters in rural schools, he went to Yale. He appears to have paid his own way through college by the exercise of his mechanical talents. He is said to have mended for the college some imported apparatus which otherwise would have had to go to the old country for repairs. "There was a good mechanic spoiled when you came to college," he was told by a carpenter in the town. There was no "Sheff" at Yale in those days to give young men like Whitney scientific instruction; so, defying the bent of his abilities, Eli went on with his academic studies, graduated in 1792, at the age of twenty-seven, and decided to be a teacher or perhaps a lawyer.

Like so many young New Englanders of the time, Whitney sought employment in the South. Having received the promise of a position in South Carolina, he embarked at New York, soon after his graduation, on a sailing vessel bound for

Savannah. On board he met the widow of General Nathanael Greene of Revolutionary fame, and this lady invited him to visit her plantation at Mulberry Grove, near Savannah. What happened then is best told by Eli Whitney himself, in a letter to his father, written at New Haven, after his return from the South some months later, though the spelling master will probably send Whitney to the foot of the class:

New Haven, Sept. 11th, 1793.

. . . I went from N. York with the family of the late Major General Greene to Georgia. I went immediately with the family to their Plantation about twelve miles from Savannah with an expectation of spending four or five days and then proceed into Carolina to take the school as I have mentioned in former letters. During this time I heard much said of the extreme difficulty of ginning Cotton, that is, seperating it from its seeds. There were a number of very respectable Gentlemen at Mrs. Greene's who all agreed that if a machine could be invented which would clean the cotton with expedition, it would be a great thing both to the Country and to the inventor. I involuntarily happened to be thinking on the subject and struck out a plan of a Machine in my mind, which I communicated to Miller (who is agent to the Executors of Genl. Greene and resides in the family, a man of respectibility and property), he was pleased with the Plan and said if I would pursue it and try an experi-

ment to see if it would answer, he would be at the whole expense, I should loose nothing but my time, and if I succeeded we would share the profits. Previous to this I found I was like to be disappointed in my school, that is, instead of a hundred, I found I could get only fifty Guineas a year. I however held the refusal of the school untill I tried some experiments. In about ten Days I made a little model, for which I was offered, if I would give up all right and title to it, a Hundred Guineas. I concluded to relinquish my school and turn my attention to perfecting the Machine. I made one before I came away which required the labor of one man to turn it and with which one man will clean ten times as much cotton as he can in any other way before known and also cleanse it much better than in the usual mode. This machine may be turned by water or with a horse, with the greatest ease, and one man and a horse will do more than fifty men with the old machines. It makes the labor fifty times less, without throwing any class of People out of business.

I returned to the Northward for the purpose of having a machine made on a large scale and obtaining a Patent for the invention. I went to Philadelphia¹ soon after I arrived, made myself acquainted with the steps necessary to obtain a Patent, took several of the steps and the Secretary of State Mr. Jefferson agreed to send the Patent to me as soon it could be made out — so that I apprehended no difficulty in obtaining the Patent — Since I have been here I have employed several workmen in making machines and as soon as my business is such that I can leave it a few

¹ Then the national capital.

days, I shall come to Westboro'. I think it is probable I shall go to Philadelphia again before I come to Westboro', and when I do come I shall be able to stay but few days. I am certain I can obtain a patent in England. As soon as I have got a Patent in America I shall go with the machine which I am now making, to Georgia, where I shall stay a few weeks to see it at work. From thence I expect to go to England, where I shall probably continue two or three years. How advantageous this business will eventually prove to me, I cannot say. It is generally said by those who know anything about it, that I shall make a Fortune by it. I have no expectation that I shall make an independent fortune by it, but think I had better pursue it than any other business into which I can enter. Something which cannot be foreseen may frustrate my expectations and defeat my Plan; but I am now so sure of success that ten thousand dollars, if I saw the money counted out to me, would not tempt me to give up my right and relinquish the object. I wish you, sir, not to show this letter nor communicate anything of its contents to any body except My Brothers and Sister, *enjoining* it on them to keep the whole a *profound secret*.¹

The invention, however, could not be kept "a profound secret," for knowledge of it was already out in the cotton country. Whitney's hostess, Mrs. Greene, had shown the wonderful machine to

¹ Hammond, "Correspondence of Eli Whitney," *American Historical Review*, vol. III, p. 99. The other citations in this chapter are from the same source, unless otherwise stated.

some friends, who soon spread the glad tidings, and planters, near and far, had come to Mulberry Grove to see it. The machine was of very simple construction; any blacksmith or wheelwright, knowing the principle of the design, could make one. Even before Whitney could obtain his patent, cotton gins based on his were being manufactured and used.

Whitney received his patent in March, 1794, and entered on his new work with enthusiasm. His partner, Phineas Miller, was a cultivated New England gentleman, a graduate of Yale College, who, like Whitney, had sought his fortune as a teacher in the South. He had been a tutor in the Greene household and on General Greene's death had taken over the management of his estates. He afterwards married Mrs. Greene. The partners decided to manufacture the machines in New Haven, Whitney to give his time to the production, Miller to furnish the capital and attend to the firm's interests in the South.

At the outset the partners blundered seriously in their plan for commercializing the invention. They planned to buy seed cotton and clean it themselves; also to clean cotton for the planters on the familiar toll system, as in grinding grain, taking a toll of

one pound of cotton out of every three. "Whitney's plan in Georgia," says a recent writer, "as shown by his letters and other evidence, was to own all the gins and gin all the cotton made in the country. It is but human nature that this sort of monopoly should be odious to any community."¹ Miller appears to have calculated that the planters could afford to pay for the use of the new invention about one-half of all the profits they derived from its use. An equal division, between the owners of the invention on the one hand and the cotton growers on the other, of all the superadded wealth arising from the invention, seemed to him fair. Apparently the full meaning of such an arrangement did not enter his mind. Perhaps Miller and Whitney did not see at first that the new invention would cause a veritable industrial revolution, or that the system they planned, if it could be made effective, would make them absolute masters of the cotton country, with the most stupendous monopoly in the world. Nor do they appear to have realized that, considering the simple construction of their machine and the loose operation of the patent law at that time, the planters of the South would never submit to so great a tribute as they

¹ Tompkins, *Cotton and Cotton Oil*, p. 26.

proposed to exact. Their attempt in the first instance to set up an unfair monopoly brought them presently into a sea of troubles, which they never passed out of, even when they afterwards changed their tack and offered to sell the machines with a license, or a license alone, at a reasonable price.

Misfortune pursued the partners from the beginning. Whitney writes to his father from New Haven in May, 1794, that his machines in Georgia are working well, but that he apprehends great difficulty in manufacturing them as fast as they are needed. In March of the following year he writes again, saying that his factory in New Haven has been destroyed by fire: "When I returned home from N. York I found my property all in ashes! My shop, all my tools, material and work equal to twenty finished cotton machines all gone. The manner in which it took fire is altogether unaccountable." Besides, the partners found themselves in distress for lack of capital. Then word came from England that the Manchester spinners had found the ginned cotton to contain knots, and this was sufficient to start the rumor throughout the South that Whitney's gin injured the cotton fiber and that cotton cleaned by them was worthless. It was two years before this ghost was laid.

Meanwhile Whitney's patent was being infringed on every hand. "They continue to clean great quantities of cotton with Lyon's Gin and sell it advantageously while the Patent ginned cotton is run down as good for nothing," writes Miller to Whitney in September, 1797. Miller and Whitney brought suits against the infringers but they could obtain no redress in the courts.

Whitney's attitude of mind during these troubles is shown in his letters. He says the statement that his machines injure the cotton is false, that the source of the trouble is bad cotton, which he ventures to think is improved fifty per cent by the use of his gin, and that it is absurd to say that the cotton could be injured in any way in the process of cleaning. "I think," he says, writing to Miller, "you will be able to convince the *candid* that this is quite a mistaken notion and them that *will not believe* may be damn'd." Again, writing later to his friend Josiah Stebbins in New England: "I have a set of the most Depraved villains to combat and I might almost as well go to *Hell* in search of *Happiness* as apply to a Georgia Court for Justice." And again: "You know I always believed in the '*Depravity of human nature.*' I thought I was long ago sufficiently 'grounded and stablised' in this

Doctrine. But God Almighty is continually pouring down cataracts of testimony upon me to convince me of this fact. 'Lord I believe, help thou,' not 'mine unbelief,' but me to overcome the rascality of mankind." His partner Miller, on the other hand, is inclined to be more philosophical and suggests to Whitney that "we take the affairs of this world patiently and that the little dust which we may stir up about cotton may after all not make much difference with our successors one hundred, much less one thousand years hence." Miller, however, finally concluded that, "the prospect of making anything by ginning in this State [Georgia] is at an end. Surreptitious gins are being erected in every part of the country; and the jurymen at Augusta have come to an understanding among themselves, that they will never give a verdict in our favor, let the merits of the case be as they may."¹

Miller and Whitney were somewhat more fortunate in other States than in Georgia though they nowhere received from the cotton gin enough to compensate them for their time and trouble nor more than a pitiable fraction of the great value of their invention. South Carolina, in 1801, voted

¹ Cited in Roe, *English and American Tool Builders*, p. 153.

them fifty thousand dollars for their patent rights, twenty thousand dollars to be paid down and the remainder in three annual payments of ten thousand dollars each. "We get but a song for it," wrote Whitney, "in comparison with the worth of the thing, but it is securing something." Why the partners were willing to take so small a sum was later explained by Miller. They valued the rights for South Carolina at two hundred thousand dollars, but, since the patent law was being infringed with impunity, they were willing to take half that amount; "and had flattered themselves," wrote Miller, "that a sense of dignity and justice on the part of that honorable body [the Legislature] would not have countenanced an offer of a less sum than one hundred thousand dollars. Finding themselves, however, to be mistaken in this opinion, and entertaining a belief that the failure of such negotiation, after it commenced, would have a tendency to diminish the prospect, already doubtful, of enforcing the Patent Law, it was concluded to be best under existing circumstances to accept the very inadequate sum of fifty thousand dollars offered by the Legislature and thereby relinquish and entirely abandon three-fourths of the actual value of the property."

But even the fifty thousand dollars was not collected without difficulty. South Carolina suspended the contract, after paying twenty thousand dollars, and sued Miller and Whitney for recovery of the sum paid, on the ground that the partners had not complied with the conditions. Whitney succeeded, in 1805, in getting the Legislature to reinstate the contract and pay him the remainder of the money. Miller, discouraged and broken by the long struggle, had died in the meantime.

The following passage from a letter written by Whitney in February, 1805, to Josiah Stebbins, gives Whitney's views as to the treatment he had received at the hands of the authorities. He is writing from the residence of a friend near Orangeburg, South Carolina.

The principal object of my present excursion to this Country was to get this business set right; which I have so far effected as to induce the Legislature of this State to recind all their former *Suspending Laws* and *resolutions*, to agree once more to pay the sum of 30,000 Dollars which was due and make the necessary appropriations for that purpose. I have as yet however obtained but a small part of this payment. The residue is promised me in July next. Thus you see my *recompense* of *reward* is as the land of Canaan was to the Jews, resting a long while in promise. If the Nations with whom I have to contend are not as

numerous as those opposed to the Israelites, they are certainly much greater *Heathens*, having their hearts hardened and their understanding blinded, to make, propagate and believe all manner of lies. Verily, Stebbins, I have had much vexation of spirit in this business. I shall spend forty thousand dollars to obtain thirty, and it will all end in vanity at last. A contract had been made with the State of Tennessee which now hangs *suspended*. Two attempts have been made to induce the State of No. Carolina to *recind* their *Contract*, neither of which have succeeded. Thus you see Brother Steb. Sovereign and Independent States warped by *interest* will be *rogues* and misled by Demagogues will be *fools*. They have spent much time, *money* and *Credit*, to avoid giving me a small compensation, for that which to them is worth millions.

Meanwhile North Carolina had agreed to buy the rights for the State on terms that yielded Whitney about thirty thousand dollars, and it is estimated that he received about ten thousand dollars from Tennessee, making his receipts in all about ninety thousand dollars, before deducting costs of litigation and other losses. The cotton gin was not profitable to its inventor. And yet no invention in history ever so suddenly transformed an industry and created enormous wealth. Eight years before Whitney's invention, eight bales of cotton, landed at Liverpool, were seized on the

ground that so large a quantity of cotton could not have been produced in the United States. The year before that invention the United States exported less than one hundred and forty thousand pounds of cotton; the year after it, nearly half a million pounds; the next year over a million and a half; a year later still, over six million; by 1800, nearly eighteen million pounds a year. And by 1845 the United States was producing seven-eighths of the world's cotton. Today the United States produces six to eight billion pounds of cotton annually, and ninety-nine per cent of this is the upland or green-seed cotton, which is cleaned on the Whitney type of gin and was first made commercially available by Whitney's invention.¹

More than half of this enormous crop is still exported in spite of the great demand at home. Cotton became and has continued to be the greatest single export of the United States. In ordinary years its value is greater than the combined value of the three next largest exports. It is on cotton that the United States has depended for the payment of its trade balance to Europe.

Other momentous results followed on the invention of the cotton gin. In 1793 slavery seemed a

¹ Roe, *English and American Tool Builders*, pp. 150-51.

dying institution, North and South. Conditions of soil and climate made slavery unprofitable in the North. On many of the indigo, rice, and tobacco plantations in the South there were more slaves than could be profitably employed, and many planters were thinking of emancipating their slaves, when along came this simple but wonderful machine and with it the vision of great riches in cotton; for while slaves could not earn their keep separating the cotton from its seeds by hand, they could earn enormous profits in the fields, once the difficulty of extracting the seeds was solved. Slaves were no longer a liability but an asset. The price of "field hands" rose, and continued to rise. If the worn-out lands of the seaboard no longer afforded opportunity for profitable employment, the rich new lands of the Southwest called for laborers, and yet more laborers. Taking slaves with them, younger sons pushed out into the wilderness, became possessed of great tracts of fertile land, and built up larger plantations than those upon which they had been born. Cotton became King of the South.

The supposed economic necessity of slave labor led great men to defend slavery, and politics in the South became largely the defense of slavery against

the aggression, real or fancied, of the free North. The rift between the sections became a chasm. Then came the War of Secession.

Though Miller was dead, Whitney carried on the fight for his rights in Georgia. His difficulties were increased by a patent which the Government at Philadelphia issued in May, 1796, to Hogden Holmes, a mechanic of Augusta, for an improvement in the cotton gin. The Holmes machines were soon in common use, and it was against the users of these that many of the suits for infringement were brought. Suit after suit ran its course in the Georgia courts, without a single decision in the inventor's favor. At length, however, in December, 1806, the validity of Whitney's patent was finally determined by decision of the United States Circuit Court in Georgia. Whitney asked for a perpetual injunction against the Holmes machine, and the court, finding that his invention was basic, granted him all that he asked.

By this time, however, the life of the patent had nearly run its course. Whitney applied to Congress for a renewal, but, in spite of all his arguments and a favorable committee report, the opposition from the cotton States proved too strong,

and his application was denied. Whitney now had other interests. He was a great manufacturer of firearms, at New Haven, and as such we shall meet him again in a later chapter.

CHAPTER III

STEAM IN CAPTIVITY

FOR the beginnings of the enslavement of steam, that mighty giant whose work has changed the world we live in, we must return to the times of Benjamin Franklin. James Watt, the accredited father of the modern steam engine, was a contemporary of Franklin, and his engine was twenty-one years old when Franklin died. The discovery that steam could be harnessed and made to work is not, of course, credited to James Watt. The precise origin of that discovery is unknown. The ancient Greeks had steam engines of a sort, and steam engines of another sort were pumping water out of mines in England when James Watt was born. James Watt, however, invented and applied the first effective means by which steam came to serve mankind. And so the modern steam engine begins with him.

The story is old, of how this Scottish boy, James

Watt, sat on the hearth in his mother's cottage, intently watching the steam rising from the mouth of the tea kettle, and of the great rôle which this boy afterwards assumed in the mechanical world. It was in 1763, when he was twenty-eight and had the appointment of mathematical-instrument maker to the University of Glasgow, that a model of Newcomen's steam pumping engine was brought into his shop for repairs. One can perhaps imagine the feelings with which James Watt, interested from his youth in mechanical and scientific instruments, particularly those which dealt with steam, regarded this Newcomen engine. Now his interest was vastly quickened. He set up the model and operated it, noticed how the alternate heating and cooling of its cylinder wasted power, and concluded, after some weeks of experiment, that, in order to make the engine practicable, the cylinder must be kept hot, "always as hot as the steam which entered it." Yet in order to condense the steam there must be a cooling of the vessel. The problem was to reconcile these two conditions.

At length the pregnant idea occurred to him—the idea of the separate condenser. It came to him on a Sunday afternoon in 1765, as he walked across Glasgow Green. If the steam were

condensed in a vessel separate from the cylinder, it would be quite possible to keep the condensing vessel cool and the cylinder hot at the same time. Next morning Watt began to put his scheme to the test and found it practicable. He developed other ideas and applied them. So at last was born a steam engine that would work and multiply man's energies a thousandfold.

After one or two disastrous business experiences, such as fall to the lot of many great inventors, perhaps to test their perseverance, Watt associated himself with Matthew Boulton, a man of capital and of enterprise, owner of the Soho Engineering Works, near Birmingham. The firm of Boulton and Watt became famous, and James Watt lived till August 19, 1819 — lived to see his steam engine the greatest single factor in the new industrial era that had dawned for English-speaking folk.

Boulton and Watt, however, though they were the pioneers, were by no means alone in the development of the steam engine. Soon there were rivals in the field with new types of engines. One of these was Richard Trevithick in England; another was Oliver Evans of Philadelphia. Both Trevithick and Evans invented the high-pressure engine. Evans appears to have applied the high-

pressure principle before Trevithick, and it has been said that Trevithick borrowed it from Evans, but Evans himself never said so, and it is more likely that each of these inventors worked it out independently. Watt introduced his steam to the cylinder at only slightly more than atmospheric pressure and clung tenaciously to the low-pressure theory all his life. Boulton and Watt, indeed, aroused by Trevithick's experiments in high-pressure engines, sought to have Parliament pass an act forbidding high pressure on the ground that the lives of the public were endangered. Watt lived long enough, however, to see the high-pressure steam engine come into general favor, not only in America but even in his own conservative country.

Less sudden, less dramatic, than that of the cotton gin, was the entrance of the steam engine on the American industrial stage, but not less momentous. The actions and reactions of steam in America provide the theme for an Iliad which some American Homer may one day write. They include the epic of the coal in the Pennsylvania hills, the epic of the ore, the epic of the railroad, the epic of the great city; and, in general, the subjugation of a continental wilderness to the service of a vast civilization. /

The vital need of better transportation was uppermost in the thoughts of many Americans. It was seen that there could be no national unity in a country so far flung without means of easy intercourse between one group of Americans and another. The highroads of the new country were, for the most part, difficult even for the man on horseback, and worse for those who must travel by coach or post-chaise. Inland from the coast and away from the great rivers there were no roads of any sort; nothing but trails. Highways were essential, not only for the permanent unity of the United States, but to make available the wonderful riches of the inland country, across the Appalachian barrier and around the Great Lakes, into which American pioneers had already made their way.

Those immemorial pathways, the great rivers, were the main avenues of traffic with the interior. So, of course, when men thought of improving transportation, they had in mind chiefly transportation by water; and that is why the earliest efforts of American inventors were applied to the means of improving traffic and travel by water and not by land.

The first men to spend their time in trying to apply steam power to the propulsion of a boat were

contemporaries of Benjamin Franklin. Those who worked without Watt's engine could hardly succeed. One of the earliest of these was William Henry of Pennsylvania. Henry, in 1763, had the idea of applying power to paddle wheels, and constructed a boat, but his boat sank, and no result followed, unless it may be that John Fitch and Robert Fulton, both of whom were visitors at Henry's house, received some suggestions from him. James Rumsey of Maryland began experiments as early as 1774 and by 1786 had a boat that made four miles an hour against the current of the Potomac.

The most interesting of these early and unsuccessful inventors is John Fitch, who was a Connecticut clockmaker living in Philadelphia. He was eccentric and irregular in his habits and quite ignorant of the steam engine. But he conceived the idea of a steamboat and set to work to make one. The record of Fitch's life is something of a tragedy. At the best he was an unhappy man and was always close to poverty. As a young man he had left his family because of unhappy domestic relations with his wife. One may find in the record of his undertakings which he left in the Philadelphia Library, to be opened thirty years after its receipt,

these words: "I know of nothing so perplexing and vexatious to a man of feelings as a turbulent Wife and Steamboat building." But in spite of all his difficulties Fitch produced a steamboat, which plied regularly on the Delaware for several years and carried passengers. "We reigned Lord High Admirals of the Delaware; and no other boat in the River could hold its way with us," he wrote. "Thus has been effected by little Johnny Fitch and Harry Voight [one of his associates] one of the greatest and most useful arts that has ever been introduced into the world; and although the world and my country does not thank me for it, yet it gives me heartfelt satisfaction." The "Lord High Admirals of the Delaware," however, did not reign long. The steamboat needed improvement to make it pay; its backers lost patience and faith, and the inventor gave up the fight and retired into the fastnesses of the Kentucky wilderness, where he died.

The next inventor to struggle with the problem of the steamboat, with any approach to success, was John Stevens of Hoboken. His life was cast in a vastly different environment from that of John Fitch. He was a rich man, a man of family and of influence. His father's house—afterwards

his own — at 7 Broadway, facing Bowling Green — was one of the mansions of early New York, and his own summer residence on Castle Point, Hoboken, just across the Hudson, was one of the landmarks of the great river. For many years John Stevens crossed that river; most often in an open boat propelled by sail or by men at the oars. Being naturally of a mechanical turn, he sought to make the crossing easier. To his library were coming the prints that told of James Watt and the steam engine in England, and John Fitch's boat had interested him.

Robert Fulton's *Clermont*, of which we shall speak presently, was undoubtedly the pioneer of practicable steamboats. But the *Phœnix*, built by John Stevens, followed close on the *Clermont*. And its engines were built in America, while those of the *Clermont* had been imported from England. Moreover, in June, 1808, the *Phœnix* stood to sea, and made the first ocean voyage in the history of steam navigation. Because of a monopoly of the Hudson, which the New York Legislature had granted to Livingston and Fulton, Stevens was compelled to send his ship to the Delaware. Hence the trip out into the waters of the Atlantic, a journey that was not undertaken without trepidation.

But, despite the fact that a great storm arose, the *Phœnix* made the trip in safety; and continued for many years thereafter to ply the Delaware between Philadelphia and Trenton.

Robert Fulton, like many and many another great inventor, from Leonardo da Vinci down to the present time, was also an artist. He was born November 14, 1765, at Little Britain, Lancaster County, Pennsylvania, of that stock which is so often miscalled "Scotch-Irish." He was only a child when his father died, leaving behind him a son who seems to have been much more interested in his own ideas than in his schoolbooks. Even in his childhood Robert showed his mechanical ability. There was a firm of noted gunsmiths in Lancaster, in whose shops he made himself at home and became expert in the use of tools. At the age of fourteen he applied his ingenuity to a heavy fishing boat and equipped it with paddle-wheels, which were turned by a crank, thus greatly lightening the labor of moving it.

At the age of seventeen young Fulton moved to Philadelphia and set up as a portrait painter. Some of the miniatures which he painted at this time are said to be very good. He worked hard, made many good friends, including Benjamin

Franklin, and succeeded financially. He determined to go to Europe to study — if possible under his fellow Pennsylvanian, Benjamin West, then rising into fame in London. The West and the Fulton families had been intimate, and Fulton hoped that West would take him as a pupil. First buying a farm for his mother with a part of his savings, he sailed for England in 1786, with forty guineas in his pocket. West received him not only as a pupil but as a guest in his house and introduced him to many of his friends. Again Fulton succeeded, and in 1791 two of his portraits were exhibited at the Royal Academy, and the Royal Society of British Artists hung four paintings by him.

Then came the commission which changed the course of Fulton's life. His work had attracted the notice of Viscount Courtenay, later Earl of Devon, and he was invited to Devonshire to paint that nobleman's portrait. Here he met Francis, third Duke of Bridgewater, the father of the English canal system, and his hardly less famous engineer, James Brindley, and also Earl Stanhope, a restless, inquiring spirit. Fulton the mechanic presently began to dominate Fulton the artist. He studied canals, invented a means of sawing marble in the

quarries, improved the wheel for spinning flax, invented a machine for making rope, and a method of raising canal boats by inclined planes instead of locks. What money he made from these inventions we do not know, but somewhat later (1796) he speaks hopefully of an improvement in tanning. This same year he published a pamphlet entitled *A Treatise on the Improvement of Canal Navigation*, copies of which were sent to Napoleon and President Washington.

Fulton went to France in 1797. To earn money he painted several portraits and a panorama of the Burning of Moscow. This panorama, covering the walls of a circular hall built especially for it, became very popular, and Fulton painted another. In Paris he formed a warm friendship with that singular American, Joel Barlow, soldier, poet, speculator, and diplomatist, and his wife, and for seven years lived in their house.

The long and complicated story of Fulton's sudden interest in torpedoes and submarine boats, his dealings with the Directory and Napoleon and with the British Admiralty does not belong here. His experiments and his negotiations with the two Governments occupied the greater part of his time for the years between 1797 and 1806. His

expressed purpose was to make an engine of war so terrible that war would automatically be abolished. The world, however, was not ready for diving boats and torpedoes, nor yet for the end of war, and his efforts had no tangible results.¹

During all the years after 1793, at least, and perhaps earlier, the idea of the steamboat had seldom been out of his mind, but lack of funds and the greater urgency, as he thought, of the submarine prevented him from working seriously upon it. In 1801, however, Robert R. Livingston came to France as American Minister. Livingston had already made some unsuccessful experiments with the steamboat in the United States, and, in 1798, had received the monopoly of steam navigation on the waters of New York for twenty years, provided that he produced a vessel within twelve months able to steam four miles an hour. This grant had, of course, been forfeited, but might be renewed, Livingston thought.

Fulton and Livingston met, probably at Barlow's house, and, in 1802, drew up an agreement to construct a steamboat to ply between New York

¹ The submarine was the invention of David Bushnell, a Connecticut Yankee, whose "American Turtle" blew up at least one British vessel in the War of Independence and created much consternation among the King's ships in American waters.

and Albany. Livingston agreed to advance five hundred dollars for experimentation in Europe. In this same year Fulton built a model and tested different means of propulsion, giving "the preference to a wheel on each side of the model."¹ The boat was built on the Seine, but proved too frail for the borrowed engine. A second boat was tried in August, 1803, and moved, though at a disappointingly slow rate of speed.

Just at this time Fulton wrote ordering an engine from Boulton and Watt to be transported to America. The order was at first refused, as it was then the shortsighted policy of the British Government to maintain a monopoly of mechanical contrivances. Permission to export was given the next year, however, and the engine was shipped in 1805. It lay for some time in the New York Customs House. Meanwhile Fulton had studied the Watt engine on Symington's steamboat, the *Charlotte Dundas*, on the Forth and Clyde Canal, and Livingston had been granted a renewal of his monopoly of the waters of New York.

Fulton arrived at New York in 1806 and began the construction of the *Clermont*, so named after

¹ Fulton to Barlow, quoted in Sutcliffe, *Robert Fulton and the Clermont*, p. 124.

Livingston's estate on the Hudson. The building was done on the East River. The boat excited the jeers of passers-by, who called it "Fulton's Folly." On Monday, August 17, 1807, the memorable first voyage was begun. Carrying a party of invited guests, the *Clermont* steamed off at one o'clock. Past the towns and villages along the Hudson, the boat moved steadily, black smoke rolling from her stack. Pine wood was the fuel. During the night, the sparks pouring from her funnel, the clanking of her machinery, and the splashing of the paddles frightened the animals in the woods and the occupants of the scattered houses along the banks. At one o'clock Tuesday the boat arrived at Clermont, 110 miles from New York. After spending the night at Clermont, the voyage was resumed on Wednesday. Albany, forty miles away, was reached in eight hours, making a record of 150 miles in thirty-two hours. Returning to New York, the distance was covered in thirty hours. The steamboat was a success.

The boat was then laid up for two weeks while the cabins were boarded in, a roof built over the engine, and coverings placed over the paddle-wheels to catch the spray — all under Fulton's eye. Then the *Clermont* began regular trips to Albany,

carrying sometimes a hundred passengers, making the round trip every four days, and continued until floating ice marked the end of navigation for the winter.

Why had Fulton succeeded where others had failed? There was nothing new in his boat. Every essential feature of the *Clermont* had been anticipated by one or other of the numerous experimenters before him. The answer seems to be that he was a better engineer than any of them. He had calculated proportions, and his hull and his engine were in relation. Then too, he had one of Watt's engines, undoubtedly the best at the time, and the unwavering support of Robert Livingston.

Fulton's restless mind was never still, but he did not turn capriciously from one idea to another. Though never satisfied, his new ideas were tested scientifically and the results carefully written down. Some of his notebooks read almost like geometrical demonstrations; and his drawings and plans were beautifully executed. Before his death in 1815 he had constructed or planned sixteen or seventeen boats, including boats for the Hudson, Potomac, and Mississippi rivers, for the Neva in Russia, and a steam vessel of war for the United

States. He was a member of the commission on the Erie Canal, though he did not live to see that enterprise begun.

The mighty influence of the steamboat in the development of inland America is told elsewhere in this Series.¹ The steamboat has long since grown to greatness, but it is well to remember that the true ancestor of the magnificent leviathan of our own day is the *Clermont* of Robert Fulton.

The world today is on the eve of another great development in transportation, quite as revolutionary as any that have preceded. How soon will it take place? How long before Kipling's vision in *The Night Mail* becomes a full reality? How long before the air craft comes to play a great rôle in the world's transportation? We cannot tell. But, after looking at the nearest parallel in the facts of history, each of us may make his own guess. The airship appears now to be much farther advanced than the steamboat was for many years after Robert Fulton died. Already we have seen men ride the wind above the sea from the New World to the Old. Already United States mails are regularly carried through the air from the Atlantic to

¹ Archer B. Hulbert, *The Paths of Inland Commerce*.

the Golden Gate. It was twelve years after the birth of Fulton's *Clermont*, and four years after the inventor's death, before any vessel tried to cross the Atlantic under steam. This was in 1819, when the sailing packet *Savannah*, equipped with a ninety horse-power horizontal engine and paddle-wheels, crossed from Savannah to Liverpool in twenty-five days, during eighteen of which she used steam power. The following year, however, the engine was taken out of the craft. And it was not until 1833 that a real steamship crossed the Atlantic. This time it was the *Royal William*, which made a successful passage from Quebec to London. Four years more passed before the *Great Western* was launched at Bristol, the first steamship to be especially designed for transatlantic service, and the era of great steam liners began.

If steam could be made to drive a boat on the water, why not a wagon on the land?

History, seeking origins, often has difficulty when it attempts to discover the precise origin of an idea. "It frequently happens," said Oliver Evans, "that two persons, reasoning right on a mechanical subject, think alike and invent the same thing without any communication with each

other.”¹ It is certain, however, that one of the first, if not the first, protagonist of the locomotive in America was the same Oliver Evans, a truly great inventor for whom the world was not quite ready. The world has forgotten him. But he was the first engine builder in America, and one of the best of his day. He gave to his countrymen the high-pressure steam engine and new machinery for manufacturing flour that was not superseded for a hundred years.

Evans was apprenticed at the age of fourteen to a wheelwright. He was a thoughtful, studious boy, who devoured eagerly the few books to which he had access, even by the light of a fire of shavings, when denied a candle by his parsimonious master. He says that in 1772, when only seventeen years old, he began to contrive some method of propelling land carriages by other means than animal power; and that he thought of a variety of devices, such as using the force of the wind and treadles worked by men; but as they were evidently inadequate, was about to give up the problem as unsolvable for want of a suitable source of power, when he heard that some neighboring blacksmith's boys had stopped up the touch-hole of a gun barrel, put in some water, rammed down a tight wad, and, putting the breech into the smith's fire, the gun had discharged itself with a report like that of

¹ Coleman Sellers, "Oliver Evans and His Inventions," *Journal of the Franklin Institute*, July, 1886: vol. CXXII, p. 16.

gunpowder. This immediately suggested to his fertile mind a new source of power, and he labored long to apply it, but without success, until there fell into his hands a book describing the old atmospheric steam engine of Newcomen, and he was at once struck with the fact that steam was only used to produce a vacuum while to him it seemed clear that the elastic power of the steam if applied directly to moving the piston, would be far more efficient. He soon satisfied himself that he could make steam wagons, but could convince no one else of this possibility.¹

Evans was then living in Delaware, where he was born, and where he later worked out his inventions in flour-milling machinery and invented and put into service the high-pressure steam engine. He appears to have moved to Philadelphia about 1790, the year of Franklin's death and of the Federal Patent Act; and, as we have seen, the third patent issued by the Government at Philadelphia was granted to him. About this time he became absorbed in the hard work of writing a book, the *Millwright and Miller's Guide*, which he published in 1795, but at a heavy sacrifice to himself in time and money. A few years later he had an established engine works in Philadelphia and

¹ Coleman Sellers, "Oliver Evans and His Inventions," *Journal of the Franklin Institute*, July, 1886: vol. CXXII, p. 3.

was making steam engines of his own type that performed their work satisfactorily.

The *Oruktor Amphibolos*, or Amphibious Digger, which came out of his shop in 1804, was a steam-driven machine made to the order of the Philadelphia Board of Health for dredging and cleaning the docks of the city. It was designed, as its name suggests, for service either in water or on shore. It propelled itself across the city to the river front, puffing and throwing off clouds of steam and making quite a sensation on the streets.

Evans had never forgotten his dream of the "steam wagon." His *Oruktor* had no sooner begun puffing than he offered to make for the Philadelphia and Lancaster Turnpike Company steam-driven carriages to take the place of their six-horse Conestoga wagons, promising to treble their profits. But the directors of the road were conservative men and his arguments fell on deaf ears.

In the same year Evans petitioned Congress for an extension of the patent on his flour-milling machinery, which was about to expire. He had derived little profit from this important invention, as the new machinery made its way very slowly, but every year more and more millers were using it and Evans received royalties from them. He

felt sure that Congress would renew his patent, and, with great expectations for the future, he announced a new book in preparation by himself to be called *The Young Engineer's Guide*. It was to give the most thorough treatment to the subject of the steam engine, with a profusion of drawings to illustrate the text. But Evans reckoned without the millers who were opposing his petition. Though they were profiting by his invention, they were unwilling to pay him anything, and they succeeded in having his bill in Congress defeated. It was a hard blow for the struggling author and inventor. His income cut off, he was obliged to reduce the scale of his book "and to omit many of the illustrations he had promised." He wrote the sad story into the name of the book. It came out under the title of *The Abortion of the Young Engineer's Guide*.

Four years later, when Congress restored and extended his patent, Evans felt that better days were ahead, but, as said already, he was too far ahead of his time to be understood and appreciated. Incredulity, prejudice, and opposition were his portion as long as he lived. Nevertheless, he went on building good engines and had the satisfaction of seeing them in extensive use. His life came to

an end as the result of what to him was the greatest possible tragedy. He was visiting New York City in 1819, when news came to him of the destruction by an incendiary of his beloved shops in Philadelphia. The shock was greater than he could bear. A stroke of apoplexy followed, from which he died.

The following prophecy, written by Oliver Evans and published in 1812, seventeen years before the practical use of the locomotive began, tells us something of the vision of this early American inventor:

The time will come when people will travel in stages moved by steam engines from one city to another almost as fast as birds fly — fifteen to twenty miles an hour. Passing through the air with such velocity — changing the scenes in such rapid succession — will be the most exhilarating, delightful exercise. A carriage will set out from Washington in the morning, and the passengers will breakfast at Baltimore, dine in Philadelphia, and sup at New York the same day.

To accomplish this, two sets of railways will be laid so nearly level as not in any place to deviate more than two degrees from a horizontal line, made of wood or iron, on smooth paths of broken stone or gravel, with a rail to guide the carriages so that they may pass each other in different directions and travel by night as well as by day; and the passengers will sleep in these stages as comfortably as they do now in steam stage-boats.¹

¹ Cited by Coleman Sellers, *Ibid.*, p. 13.

Another early advocate of steam carriages and railways was John Stevens, the rich inventor of Hoboken, who figures in the story of the steamboat. In February, 1812, Stevens addressed to the commissioners appointed by the State of New York to explore a route for the Erie Canal an elaborate memoir calculated to prove that railways would be much more in the public interest than the proposed canal. He wrote at the same time to Robert R. Livingston (who, as well as Robert Fulton, his partner in the steamboat, was one of the commissioners) requesting his influence in favor of railways. Livingston, having committed himself to the steamboat and holding a monopoly of navigation on the waters of New York State, could hardly be expected to give a willing ear to a rival scheme, and no one then seems to have dreamed that both canal and railway would ultimately be needed. Livingston, however, was an enlightened statesman, one of the ablest men of his day. He had played a prominent part in the affairs of the Revolution and in the ratification of the Constitution; had known Franklin and Washington and had negotiated with Napoleon the Louisiana Purchase. His reply to Stevens is a good statement of the objections to the railway, as

seen at the time, and of the public attitude towards it.

ROBERT R. LIVINGSTON TO JOHN STEVENS

ALBANY, 11th March, 1812.

I did not, till yesterday, receive yours of the 25th of February; where it has loitered on the road I am at a loss to say. I had before read your very ingenious propositions as to the rail-way communication. I fear, however, on mature reflection, that they will be liable to serious objections, and ultimately more expensive than a canal. They must be double, so as to prevent the danger of two such heavy bodies meeting. The walls on which they are placed must at least be four feet below the surface, and three above, and must be clamped with iron, and even then would hardly sustain so heavy a weight as you propose moving at the rate of four miles an hour on wheels. As to wood, it would not last a week; they must be covered with iron, and that too very thick and strong. The means of stopping these heavy carriages without a great shock, and of preventing them from running upon each other (for there would be many on the road at once) would be very difficult. In case of accidental stops, or the necessary stops to take wood and water &c many accidents would happen. The carriage of condensed water would be very troublesome. Upon the whole, I fear the expense would be much greater than that of canals, without being so convenient.¹

¹ John Stevens, *Documents Tending to Prove the Superior Advantages of Rail-Ways and Steam-Carriages over Canal Navigation*

Stevens, of course, could not convince the commissioners. "The Communication from John Stevens, Esq.," was referred to a committee, who reported in March: "That they have considered the said communication with the attention due to a gentleman whose scientific researches and knowledge of mechanical powers entitle his opinions to great respect, and are sorry not to concur in them."

Stevens, however, kept up the fight. He published all the correspondence, hoping to get aid from Congress for his design, and spread his propaganda far and wide. But the War of 1812 soon absorbed the attention of the country. Then came the Erie Canal, completed in 1825, and the extension into the Northwest of the great Cumberland Road. From St. Louis steamboats churned their way up the Missouri, connecting with the Santa Fé Trail to the Southwest and the Oregon Trail to the far Northwest. Horses, mules, and oxen carried the overland travelers, and none yet dreamed of being carried on the land by steam.

Back East, however, and across the sea in England, there were a few dreamers. Railways of

(1812). Reprinted in *The Magazine of History with Notes and Queries*, Extra Number 54 (1917).

wooden rails, sometimes covered with iron, on which wagons were drawn by horses, were common in Great Britain; some were in use very early in America. And on these railways, or tramways, men were now experimenting with steam, trying to harness it to do the work of horses. In England, Trevithick, Blenkinsop, Ericsson, Stephenson, and others; in America, John Stevens, now an old man but persistent in his plans as ever and with able sons to help him, had erected a circular railway at Hoboken as early as 1826, on which he ran a locomotive at the rate of twelve miles an hour. Then in 1828 Horatio Allen, of the Delaware and Hudson Canal Company, went over to England and brought back with him the *Stourbridge Lion*. This locomotive, though it was not a success in practice, appears to have been the first to turn a wheel on a regular railway within the United States. It was a seven days' wonder in New York when it arrived in May, 1829. Then Allen shipped it to Honesdale, Pennsylvania, where the Delaware and Hudson Canal Company had a tramway to bring down coal from the mountains to the terminal of the canal. On the crude wooden rails of this tramway Allen placed the *Stourbridge Lion* and ran it successfully at the rate of ten miles an hour. But in actual

service the *Stourbridge Lion* failed and was soon dismantled.

Pass now to Rainhill, England, and witness the birth of the modern locomotive, after all these years of labor. In the same year of 1829, on the morning of the 6th of October, a great crowd had assembled to see an extraordinary race — a race, in fact, without any parallel or precedent whatsoever. There were four entries but one dropped out, leaving three: *The Novelty*, John Braithwaite and John Ericsson; *The Sanspareil*, Timothy Hackworth; *The Rocket*, George and Robert Stephenson. These were not horses; they were locomotives. The directors of the London and Manchester Railway had offered a prize of five hundred pounds for the best locomotive, and here they were to try the issue.

The contest resulted in the triumph of Stephenson's *Rocket*. The others fell early out of the race. *The Rocket* alone met all the requirements and won the prize. So it happened that George Stephenson came into fame and has ever since lived in popular memory as the father of the locomotive. There was nothing new in his *Rocket*, except his own workmanship. Like Robert Fulton, he appears to have succeeded where others failed because he was a

sounder engineer, or a better combiner of sound principles into a working whole, than any of his rivals.

Across the Atlantic came the news of Stephenson's remarkable success. And by this time railroads were beginning in various parts of the United States: the Mohawk and Hudson, from Albany to Schenectady; the Baltimore and Ohio; the Charleston and Hamburg in South Carolina; the Camden and Amboy, across New Jersey. Horses, mules, and even sails, furnished the power for these early railroads. It can be imagined with what interest the owners of these roads heard that at last a practicable locomotive was running in England.

This news stimulated the directors of the Baltimore and Ohio to try the locomotive. They had not far to go for an experiment, for Peter Cooper, proprietor of the Canton Iron Works in Baltimore, had already designed a small locomotive, the *Tom Thumb*. This was placed on trial in August, 1830, and is supposed to have been the first American-built locomotive to do work on rails, though nearly coincident with it was the *Best Friend of Charleston*, built by the West Point Foundry, New York, for the Charleston and Hamburg Railroad. It is often difficult, as we have seen, to say which of two or

several things was first. It appears as though the little *Tom Thumb* was the first engine built in America which actually pulled weight on a regular railway, while the much larger *Best Friend* was the first to haul cars in regular daily service.

The West Point Foundry followed its first success with the *West Point*, which also went into service on the Charleston and Hamburg Railroad, and then built for the newly finished Mohawk and Hudson (the first link in the New York Central Lines) the historic *De Witt Clinton*. This primitive locomotive and the cars it drew may be seen today in the Grand Central Station in New York.

Meanwhile, the Stevens brothers, sons of John Stevens, were engaged in the construction of the Camden and Amboy Railroad. The first locomotive to operate on this road was built in England by George Stephenson. This was the *John Bull*, which arrived in the summer of 1831 and at once went to work. The *John Bull* was a complete success and had a distinguished career. Sixty-two years old, in 1893, it went to Chicago, to the Columbian Exposition, under its own steam. The *John Bull* occupies a place today in the National Museum at Washington.

With the locomotive definitely accepted, men

began to turn their minds towards its improvement and development, and locomotive building soon became a leading industry in America. At first the British types and patterns were followed, but it was not long before American designers began to depart from the British models and to evolve a distinctively American type. In the development of this type great names have been written into the industrial history of America, among which the name of Matthias Baldwin of Philadelphia probably ranks first. But there have been hundreds of great workers in this field. From Stephenson's *Rocket* and the little *Tom Thumb* of Peter Cooper, to the powerful "Mallets" of today, is a long distance — not spanned in ninety years save by the genius and restless toil of countless brains and hands.

If the locomotive could not remain as it was left by Stephenson and Cooper, neither could the stationary steam engine remain as it was left by James Watt and Oliver Evans. Demands increasing and again increasing, year after year, forced the steam engine to grow in order to meet its responsibilities. There were men living in Philadelphia in 1876, who had known Oliver Evans personally; at least one

old man at the Centennial Exhibition had himself seen the *Oruktor Amphibolos* and recalled the consternation it had caused on the streets of the city in 1804. It seemed a far cry back to the *Oruktor* from the great and beautiful engine, designed by George Henry Corliss, which was then moving all the vast machinery of the Centennial Exhibition. But since then achievements in steam have dwarfed even the great work of Corliss. And to do a kind of herculean task that was hardly dreamed of in 1876 another type of engine has made its entrance: the steam turbine, which sends its awful energy, transformed into electric current, to light a million lamps or to turn ten thousand wheels on distant streets and highways.

CHAPTER IV

SPINDLE, LOOM, AND NEEDLE IN NEW ENGLAND

THE major steps in the manufacture of clothes are four: first to harvest and clean the fiber or wool; second, to card it and spin it into threads; third, to weave the threads into cloth; and, finally to fashion and sew the cloth into clothes. We have already seen the influence of Eli Whitney's cotton gin on the first process, and the series of inventions for spinning and weaving, which so profoundly changed the textile industry in Great Britain, has been mentioned. It will be the business of this chapter to tell how spinning and weaving machinery was introduced into the United States and how a Yankee inventor laid the keystone of the arch of clothing machinery by his invention of the sewing machine.

Great Britain was determined to keep to herself the industrial secrets she had gained. According to the economic beliefs of the eighteenth century,

which gave place but slowly to the doctrines of Adam Smith, monopoly rather than cheap production was the road to success. The laws therefore forbade the export of English machinery or drawings and specifications by which machines might be constructed in other countries. Some men saw a vast prosperity for Great Britain, if only the mystery might be preserved.

Meanwhile the stories of what these machines could do excited envy in other countries, where men desired to share in the industrial gains. And, even before Eli Whitney's cotton gin came to provide an abundant supply of raw material, some Americans were struggling to improve the old hand loom, found in every house, and to make some sort of a spinning machine to replace the spinning wheel by which one thread at a time was laboriously spun.

East Bridgewater, Massachusetts, was the scene of one of the earliest of these experiments. There in 1786 two Scotchmen, who claimed to understand Arkwright's mechanism, were employed to make spinning machines, and about the same time another attempt was made at Beverly. In both instances the experiments were encouraged by the State and assisted with grants of money. The machines, operated by horse power, were crude,

and the product was irregular and unsatisfactory. Then three men at Providence, Rhode Island, using drawings of the Beverly machinery, made machines having thirty-two spindles which worked indifferently. The attempt to run them by water power failed, and they were sold to Moses Brown of Pawtucket, who with his partner, William Almy, had mustered an army of hand-loom weavers in 1790, large enough to produce nearly eight thousand yards of cloth in that year. Brown's need of spinning machinery, to provide his weavers with yarn, was very great; but these machines he had bought would not run, and in 1790 there was not a single successful power-spinner in the United States.

Meanwhile Benjamin Franklin had come home, and the Pennsylvania Society for the Encouragement of Manufactures and Useful Arts was offering prizes for inventions to improve the textile industry. And in Milford, England, was a young man named Samuel Slater, who, on hearing that inventive genius was munificently rewarded in America, decided to migrate to that country. Slater at the age of fourteen had been apprenticed to Jedediah Strutt, a partner of Arkwright. He had served both in the counting-house and the mill and had had every opportunity to learn the whole business.

Soon after attaining his majority, he landed in New York, November, 1789, and found employment. From New York he wrote to Moses Brown of Pawtucket, offering his services, and that old Quaker, though not giving him much encouragement, invited him to Pawtucket to see whether he could run the spindles which Brown had bought from the men of Providence. "If thou canst do what thou sayest," wrote Brown, "I invite thee to come to Rhode Island."

Arriving in Pawtucket in January, 1790, Slater pronounced the machines worthless, but convinced Almy and Brown that he knew his business, and they took him into partnership. He had no drawings or models of the English machinery, except such as were in his head, but he proceeded to build machines, doing much of the work himself. On December 20, 1790, he had ready carding, drawing, and roving machines and seventy-two spindles in two frames. The water-wheel of an old fulling mill furnished the power — and the machinery ran.

Here then was the birth of the spinning industry in the United States. The "Old Factory," as it was to be called for nearly a hundred years, was built at Pawtucket in 1793. Five years later Slater and others built a second mill, and in 1806.

after Slater had brought out his brother to share his prosperity, he built another. Workmen came to work for him solely to learn his machines, and then left him to set up for themselves. The knowledge he had brought soon became widespread. Mills were built not only in New England but in other States. In 1809 there were sixty-two spinning mills in operation in the country, with thirty-one thousand spindles; twenty-five more mills were building or projected, and the industry was firmly established in the United States. The yarn was sold to housewives for domestic use or else to professional weavers who made cloth for sale. This practice was continued for years, not only in New England, but also in those other parts of the country where spinning machinery had been introduced.

By 1810, however, commerce and the fisheries had produced considerable fluid capital in New England which was seeking profitable employment, especially as the Napoleonic Wars interfered with American shipping; and since Whitney's gins in the South were now piling up mountains of raw cotton, and Slater's machines in New England were making this cotton into yarn, it was inevitable that the next step should be the power loom, to

convert the yarn into cloth. So Francis Cabot Lowell, scion of the New England family of that name, an importing merchant of Boston, conceived the idea of establishing weaving mills in Massachusetts. On a visit to Great Britain in 1811, Lowell met at Edinburgh Nathan Appleton, a fellow merchant of Boston, to whom he disclosed his plans and announced his intention of going to Manchester to gain all possible information concerning the new industry. Two years afterwards, according to Appleton's account, Lowell and his brother-in-law, Patrick T. Jackson, conferred with Appleton at the Stock Exchange in Boston. They had decided, they said, to set up a cotton factory at Waltham and invited Appleton to join them in the adventure, to which he readily consented. Lowell had not been able to obtain either drawings or model in Great Britain, but he had nevertheless designed a loom and had completed a model which seemed to work.

The partners took in with them Paul Moody of Amesbury, an expert machinist, and by the autumn of 1814 looms were built and set up at Waltham. Carding, drawing, and roving machines were also built and installed in the mill, these machines gaining greatly, at Moody's expert

hands, over their American rivals. This was the first mill in the United States, and one of the first in the world, to combine under one roof all the operations necessary to convert raw fiber into cloth, and it proved a success. Lowell, says his partner Appleton, "is entitled to the credit for having introduced the new system in the cotton manufacture." Jackson and Moody "were men of unsurpassed talent," but Lowell "was the informing soul, which gave direction and form to the whole proceeding."

The new enterprise was needed, for the War of 1812 had cut off imports. The beginnings of the protective principle in the United States tariff are now to be observed. When the peace came and Great Britain began to dump goods in the United States, Congress, in 1816, laid a minimum duty of six and a quarter cents a yard on imported cottons; the rate was raised in 1824 and again in 1828. It is said that Lowell was influential in winning the support of John C. Calhoun for the impost of 1816.

Lowell died in 1817, at the early age of forty-two, but his work did not die with him. The mills he had founded at Waltham grew exceedingly prosperous under the management of Jackson; and it was not long before Jackson and his partners

Appleton and Moody were seeking wider opportunities. By 1820 they were looking for a suitable site on which to build new mills, and their attention was directed to the Pawtucket Falls, on the Merrimac River. The land about this great water power was owned by the Pawtucket Canal Company, whose canal, built to improve the navigation of the Merrimac, was not paying satisfactory profits. The partners proceeded to acquire the stock of this company and with it the land necessary for their purpose, and in December, 1821, they executed Articles of Association for the Merrimac Manufacturing Company, admitting some additional partners, among them Kirk Boott who was to act as resident agent and manager of the new enterprise, since Jackson could not leave his duties at Waltham.

The story of the enterprise thus begun forms one of the brightest pages in the industrial history of America; for these partners had the wisdom and foresight to make provision at the outset for the comfort and well-being of their operatives. Their mill hands were to be chiefly girls drawn from the rural population of New England, strong and intelligent young women, of whom there were at that time great numbers seeking employment,

since household manufactures had come to be largely superseded by factory goods. And one of the first questions which the partners considered was whether the change from farm to factory life would effect for the worse the character of these girls. This, says Appleton, "was a matter of deep interest. The operatives in the manufacturing cities of Europe were notoriously of the lowest character for intelligence and morals. The question therefore arose, and was deeply considered, whether this degradation was the result of the peculiar occupation or of other and distinct causes. We could not perceive why this peculiar description of labor should vary in its effects upon character from all other occupations." And so we find the partners voting money, not only for factory buildings and machinery, but for comfortable boarding-houses for the girls, and planning that these boarding-houses should have "the most efficient guards," that they should be in "charge of respectable women, with every provision for religious worship." They voted nine thousand dollars for a church building and further sums later for a library and a hospital.

The wheels of the first mill were started in September, 1823. Next year the partners petitioned

the Legislature to have their part of the township set off to form a new town. One year later still they erected three new mills; and in another year (1826) the town of Lowell was incorporated.

The year 1829 found the Lowell mills in straits for lack of capital, from which, however, they were promptly relieved by two great merchants of Boston, Amos and Abbott Lawrence, who now became partners in the business and who afterwards founded the city named for them farther down on the Merrimac River.

The story of the Lowell cotton factories, for twenty years, more or less, until the American girls operating the machines came to be supplanted by French Canadians and Irish, is appropriately summed up in the title of a book which describes the factory life in Lowell during those years. The title of this book is *An Idyl of Work* and it was written by Lucy Larcom, who was herself one of the operatives and whose mother kept one of the corporation boarding-houses. And Lucy Larcom was not the only one of the Lowell "factory girls" who took to writing and lecturing. There were many others, notably, Harriet Hanson (later Mrs. W. S. Robinson), Harriot Curtis ("Mina Myrtle"), and Harriet Farley; and many of the "factory

girls" married men who became prominent in the world. There was no thought among them that there was anything degrading in factory work. Most of the girls came from the surrounding farms, to earn money for a trousseau, to send a brother through college, to raise a mortgage, or to enjoy the society of their fellow workers, and have a good time in a quiet, serious way, discussing the sermons and lectures they heard and the books they read in their leisure hours. They had numerous "improvement circles" at which contributions of the members in both prose and verse were read and discussed. And for several years they printed a magazine, *The Lowell Offering*, which was entirely written and edited by girls in the mills.

Charles Dickens visited Lowell in the winter of 1842 and recorded his impressions of what he saw there in the fourth chapter of his *American Notes*. He says that he went over several of the factories, "examined them in every part; and saw them in their ordinary working aspect, with no preparation of any kind, or departure from their ordinary every-day proceedings"; that the girls "were all well dressed: and that phrase necessarily includes extreme cleanliness. They had serviceable bonnets, good warm cloaks, and shawls. . . . Moreover,

there were places in the mill in which they could deposit these things without injury; and there were conveniences for washing. They were healthy in appearance, many of them remarkably so, and had the manners and deportment of young women; not of degraded brutes of burden." Dickens continues: "The rooms in which they worked were as well ordered as themselves. In the windows of some there were green plants, which were trained to shade the glass; in all, there was as much fresh air, cleanliness, and comfort as the nature of the occupation would possibly admit of." Again: "They reside in various boarding-houses near at hand. The owners of the mills are particularly careful to allow no persons to enter upon the possession of these houses, whose characters have not undergone the most searching and thorough enquiry." Finally, the author announces that he will state three facts which he thinks will startle his English readers: "Firstly, there is a joint-stock piano in a great many of the boarding-houses. Secondly, nearly all these young ladies subscribe to circulating libraries. Thirdly, they have got up among themselves a periodical called *THE LOWELL OFFERING* . . . whereof I brought away from Lowell four hundred good solid pages, which I have read

from beginning to end.” And: “Of the merits of the *Lowell Offering* as a literary production, I will only observe, putting entirely out of sight the fact of the articles having been written by these girls after the arduous labors of the day, that it will compare advantageously with a great many English Annuals.”

The efficiency of the New England mills was extraordinary. James Montgomery, an English cotton manufacturer, visited the Lowell mills two years before Dickens and wrote after his inspection of them that they produced “a greater quantity of yarn and cloth from each spindle and loom (in a given time) than was produced by any other factories, without exception in the world.” Long before that time, of course, the basic type of loom had changed from that originally introduced, and many New England inventors had been busy devising improved machinery of all kinds.

Such were the beginnings of the great textile mills of New England. The scene today is vastly changed. Productivity has been multiplied by invention after invention, by the erection of mill after mill, and by the employment of thousands of hands in place of hundreds. Lowell as a textile

center has long been surpassed by other cities. The scene in Lowell itself is vastly changed. If Charles Dickens could visit Lowell today, he would hardly recognize in that city of modern factories, of more than a hundred thousand people, nearly half of them foreigners, the Utopia of 1842 which he saw and described.

The cotton plantations in the South were flourishing, and Whitney's gins were cleaning more and more cotton; the sheep of a thousand hills were giving wool; Arkwright's machines in England, introduced by Slater into New England, were spinning the cotton and wool into yarn; Cartwright's looms in England and Lowell's improvements in New England were weaving the yarn into cloth; but as yet no practical machine had been invented to sew the cloth into clothes.

There were in the United States numerous small workshops where a few tailors or seamstresses, gathered under one roof, laboriously sewed garments together, but the great bulk of the work, until the invention of the sewing machine, was done by the wives and daughters of farmers and sailors in the villages around Boston, New York, and Philadelphia. In these cities the garments

were cut and sent out to the dwellings of the poor to be sewn. The wages of the laborers were notoriously inadequate, though probably better than in England. Thomas Hood's ballad *The Song of the Shirt*, published in 1843, depicts the hardships of the English woman who strove to keep body and soul together by means of the needle:

With fingers weary and worn,
With eyelids heavy and red,
A woman sat in unwomanly rags,
Plying her needle and thread.

Meanwhile, as Hood wrote and as the whole English people learned by heart his vivid lines, as great ladies wept over them and street singers sang them in the darkest slums of London, a man, hungry and ill-clad, in an attic in far-away Cambridge, Massachusetts, was struggling to put into metal an idea to lighten the toil of those who lived by the needle. His name was Elias Howe and he hailed from Eli Whitney's old home, Worcester County, Massachusetts. There Howe was born in 1819. His father was an unsuccessful farmer, who also had some small mills, but seems to have succeeded in nothing he undertook.

Young Howe led the ordinary life of a New

England country boy, going to school in winter and working about the farm until the age of sixteen, handling tools every day, like any farmer's boy of the time. Hearing of high wages and interesting work in Lowell, that growing town on the Merrimac, he went there in 1835 and found employment; but two years later, when the panic of 1837 came on, he left Lowell and went to work in a machine shop in Cambridge. It is said that, for a time, he occupied a room with his cousin, Nathaniel P. Banks, who rose from bobbin-boy in a cotton mill to Speaker of the United States House of Representatives and Major-General in the Civil War.

Next we hear of Howe in Boston, working in the shop of Ari Davis, an eccentric maker and repairer of fine machinery. Here the young mechanic heard of the desirability of a sewing machine and began to puzzle over the problem. Many an inventor before him had attempted to make sewing machines and some had just fallen short of success. Thomas Saint, an Englishman, had patented one fifty years earlier; and about this very time a Frenchman named Thimmonier was working eighty sewing machines making army uniforms, when needle workers of Paris, fearing that the bread was to be taken from them, broke into his

workroom and destroyed the machines. Thimmonier tried again, but his machine never came into general use. Several patents had been issued on sewing machines in the United States, but without any practical result. An inventor named Walter Hunt had discovered the principle of the lock-stitch and had built a machine but had wearied of his work and abandoned his invention, just as success was in sight. But Howe knew nothing of any of these inventors. There is no evidence that he had ever seen the work of another.

The idea obsessed him to such an extent that he could do no other work, and yet he must live. By this time he was married and had children, and his wages were only nine dollars a week. Just then an old schoolmate, George Fisher, agreed to support his family and furnish him with five hundred dollars for materials and tools. The attic in Fisher's house in Cambridge was Howe's workroom. His first efforts were failures, but all at once the idea of the lock-stitch came to him. Previously all machines (except Hunt's, which was unknown, not having even been patented) had used the chain-stitch, wasteful of thread and easily unraveled. The two threads of the lock-stitch cross in the materials joined together, and the lines of stitches

show the same on both sides. In short, the chain-stitch is a crochet or knitting stitch, while the lock-stitch is a weaving stitch. Howe had been working at night and was on his way home, gloomy and despondent, when this idea dawned on his mind, probably rising out of his experience in the cotton mill. The shuttle would be driven back and forth as in a loom, as he had seen it thousands of times, and passed through a loop of thread which the curved needle would throw out on the other side of the cloth; and the cloth would be fastened to the machine vertically by pins. A curved arm would ply the needle with the motion of a pick-axe. A handle attached to the fly-wheel would furnish the power.

On that design Howe made a machine which, crude as it was, sewed more rapidly than five of the swiftest needle workers. But apparently to no purpose. His machine was too expensive, it could sew only a straight seam, and it might easily get out of order. The needle workers were opposed, as they have generally been, to any sort of labor-saving machinery, and there was no manufacturer willing to buy even one machine at the price Howe asked, three hundred dollars.

Howe's second model was an improvement on

the first. It was more compact and it ran more smoothly. He had no money even to pay the fees necessary to get it patented. Again Fisher came to the rescue and took Howe and his machine to Washington, paying all the expenses, and the patent was issued in September, 1846. But, as the machine still failed to find buyers, Fisher gave up hope. He had invested about two thousand dollars which seemed gone forever, and he could not, or would not, invest more. Howe returned temporarily to his father's farm, hoping for better times.

Meanwhile Howe had sent one of his brothers to London with a machine to see if a foothold could be found there, and in due time an encouraging report came to the destitute inventor. A corset-maker named Thomas had paid two hundred and fifty pounds for the English rights and had promised to pay a royalty of three pounds on each machine sold. Moreover, Thomas invited the inventor to London to construct a machine especially for making corsets. Howe went to London and later sent for his family. But after working eight months on small wages, he was as badly off as ever, for, though he had produced the desired machine, he quarrelled with Thomas and their relations came to an end.

An acquaintance, Charles Inglis, advanced Howe a little money while he worked on another model. This enabled Howe to send his family home to America, and then, by selling his last model and pawning his patent rights, he raised enough money to take passage himself in the steerage in 1848, accompanied by Inglis, who came to try his fortune in the United States.

Howe landed in New York with a few cents in his pocket and immediately found work. But his wife was dying from the hardships she had suffered, due to stark poverty. At her funeral, Howe wore borrowed clothes, for his only suit was the one he wore in the shop.

Then, soon after his wife had died, Howe's invention came into its own. It transpired presently that sewing machines were being made and sold and that these machines were using the principles covered by Howe's patent. Howe found an ally in George W. Bliss, a man of means, who had faith in the machine and who bought out Fisher's interest and proceeded to prosecute infringers. Meanwhile Howe went on making machines — he produced fourteen in New York during 1850 — and never lost an opportunity to show the merits of the invention which was being advertised and

brought to notice by the activities of some of the infringers, particularly by Isaac M. Singer, the best business man of them all. Singer had joined hands with Walter Hunt and Hunt had tried to patent the machine which he had abandoned nearly twenty years before.

The suits dragged on until 1854, when the case was decisively settled in Howe's favor. His patent was declared basic, and all the makers of sewing machines must pay him a royalty of twenty-five dollars on every machine. So Howe woke one morning to find himself enjoying a large income, which in time rose as high as four thousand dollars a week, and he died in 1867 a rich man.

Though the basic nature of Howe's patent was recognized, his machine was only a rough beginning. Improvements followed, one after another, until the sewing machine bore little resemblance to Howe's original. John Bachelder introduced the horizontal table upon which to lay the work. Through an opening in the table, tiny spikes in an endless belt projected and pushed the work forward continuously. Allan B. Wilson devised a rotary hook carrying a bobbin to do the work of the shuttle, and also the small serrated bar which pops up through the table near the needle, moves

forward a tiny space, carrying the cloth with it, drops down just below the upper surface of the table, and returns to its starting point, to repeat over and over again this series of motions. This simple device brought its owner a fortune. Isaac M. Singer, destined to be the dominant figure of the industry; patented in 1851 a machine stronger than any of the others and with several valuable features, notably the vertical presser foot held down by a spring; and Singer was the first to adopt the treadle, leaving both hands of the operator free to manage the work. His machine was good, but, rather than its surpassing merits, it was his wonderful business ability that made the name of Singer a household word.

By 1856 there were several manufacturers in the field, threatening war on each other. All men were paying tribute to Howe, for his patent was basic, and all could join in fighting him, but there were several other devices almost equally fundamental, and even if Howe's patents had been declared void it is probable that his competitors would have fought quite as fiercely among themselves. At the suggestion of George Gifford, a New York attorney, the leading inventors and manufacturers agreed to pool their inventions and to establish a fixed license

fee for the use of each. This "combination" was composed of Elias Howe, Wheeler and Wilson, Grover and Baker, and I. M. Singer, and dominated the field until after 1877, when the majority of the basic patents expired. The members manufactured sewing machines and sold them in America and Europe. Singer introduced the installment plan of sale, to bring the machine within reach of the poor, and the sewing-machine agent, with a machine or two on his wagon, drove through every small town and country district, demonstrating and selling. Meanwhile the price of the machines steadily fell, until it seemed that Singer's slogan, "A machine in every home!" was in a fair way to be realized, had not another development of the sewing machine intervened.

This was the development of the ready-made clothing industry. In the earlier days of the nation, though nearly all the clothing was of domestic manufacture, there were tailors and seamstresses in all the towns and many of the villages, who made clothing to order. Sailors coming ashore sometimes needed clothes at once, and apparently a merchant of New Bedford was the first to keep a stock on hand. About 1831, George Opdyke, later Mayor of New York, began the manufacture

of clothing on Hudson Street, which he sold largely through a store in New Orleans. Other firms began to reach out for this Southern trade, and it became important. Southern planters bought clothes not only for their slaves but for their families. The development of California furnished another large market. A shirt factory was established, in 1832, on Cherry and Market Streets, New York. But not until the coming of the power-driven sewing machine could there be any factory production of clothes on a large scale. Since then the clothing industry has become one of the most important in the country. The factories have steadily improved their models and materials, and at the present day only a negligible fraction of the people of the United States wear clothes made to their order.

The sewing machine today does many things besides sewing a seam. There are attachments which make buttonholes, darn, embroider, make ruffles or hems, and dozens of other things. There are special machines for every trade, some of which deal successfully with refractory materials.

The Singer machine of 1851 was strong enough to sew leather and was almost at once adopted by the shoemakers. These craftsmen flourished chiefly in Massachusetts, and they had traditions

reaching back at least to Philip Kertland, who came to Lynn in 1636 and taught many apprentices. Even in the early days before machinery, division of labor was the rule in the shops of Massachusetts. One workman cut the leather, often tanned on the premises; another sewed the uppers together, while another sewed on the soles. Wooden pegs were invented in 1811 and came into common use about 1815 for the cheaper grades of shoes. Soon the practice of sending out the uppers to be done by women in their own homes became common. These women were wretchedly paid, and when the sewing machine came to do the work better than it could be done by hand, the practice of "putting out" work gradually declined.

That variation of the sewing machine which was to do the more difficult work of sewing the sole to the upper was the invention of a mere boy, Lyman R. Blake. The first model, completed in 1858, was imperfect, but Blake was able to interest Gordon McKay, of Boston, and three years of patient experimentation and large expenditure followed. The McKay sole-sewing machine, which they produced, came into use, and for twenty-one years was used almost universally both in the United States and Great Britain. But this, like all the

other useful inventions, was in time enlarged and greatly improved, and hundreds of other inventions have been made in the shoe industry. There are machines to split leather, to make the thickness absolutely uniform, to sew the uppers, to insert eyelets, to cut out heel tops, and many more. In fact, division of labor has been carried farther in the making of shoes than in most industries, for there are said to be about three hundred separate operations in making a pair of shoes.

From small beginnings great industries have grown. It is a far cry from the slow, clumsy machine of Elias Howe, less than three-quarters of a century ago, to the great factories of today, filled with special models, run at terrific speed by electric current, and performing tasks which would seem to require more than human intelligence and skill.

CHAPTER V

THE AGRICULTURAL REVOLUTION

THE Census of 1920 shows that hardly thirty per cent of the people are today engaged in agriculture, the basic industry of the United States, as compared with perhaps ninety per cent when the nation began. Yet American farmers, though constantly diminishing in proportion to the whole population, have always been, and still are, able to feed themselves and all their fellow Americans and a large part of the outside world as well. They bring forth also not merely foodstuffs, but vast quantities of raw material for manufacture, such as cotton, wool, and hides. This immense productivity is due to the use of farm machinery on a scale seen nowhere else in the world. There is still, and always will be, a good deal of hard labor on the farm. But invention has reduced the labor and has made possible the carrying on of this vast industry by a relatively small number of hands.

The farmers of Washington's day had no better tools than had the farmers of Julius Cæsar's day; in fact, the Roman ploughs were probably superior to those in general use in America eighteen centuries later. "The machinery of production," says Henry Adams, "showed no radical difference from that familiar in ages long past. The Saxon farmer of the eighth century enjoyed most of the comforts known to Saxon farmers of the eighteenth."¹ One type of plough in the United States was little more than a crooked stick with an iron point attached, sometimes with rawhide, which simply scratched the ground. Ploughs of this sort were in use in Illinois as late as 1812. There were a few ploughs designed to turn a furrow, often simply heavy chunks of tough wood, rudely hewn into shape, with a wrought-iron point clumsily attached. The moldboard was rough and the curves of no two were alike. Country blacksmiths made ploughs only on order and few had patterns. Such ploughs could turn a furrow in soft ground — if the oxen were strong enough — but the friction was so great that three men and four or six oxen were required to turn a furrow where the sod was tough.

¹ *History of the United States*, vol. I, p. 16.

Thomas Jefferson had worked out very elaborately the proper curves of the moldboard, and several models had been constructed for him. He was, however, interested in too many things ever to follow any one to the end, and his work seems to have had little publicity. The first real inventor of a practicable plough was Charles Newbold, of Burlington County, New Jersey, to whom a patent for a cast-iron plough was issued in June, 1797. But the farmers would have none of it. They said it "poisoned the soil" and fostered the growth of weeds. One David Peacock received a patent in 1807, and two others later. Newbold sued Peacock for infringement and recovered damages. Pieces of Newbold's original plough are in the museum of the New York Agricultural Society at Albany.

Another inventor of ploughs was Jethro Wood, a blacksmith of Scipio, New York, who received two patents, one in 1814 and the other in 1819. His plough was of cast iron, but in three parts, so that a broken part might be renewed without purchasing an entire plough. This principle of standardization marked a great advance. The farmers by this time were forgetting their former prejudices, and many ploughs were sold. Though

Wood's original patent was extended, infringements were frequent, and he is said to have spent his entire property in prosecuting them.

In clay soils these ploughs did not work well, as the more tenacious soil stuck to the iron moldboard instead of curling gracefully away. In 1833, (John Lane), a Chicago blacksmith, faced a wooden moldboard with an old steel saw. It worked like magic, and other blacksmiths followed suit to such an extent that the demand for old saws became brisk. Then came (John Deere), a native of Vermont, who settled first in Grand Detour, and then in Moline, Illinois. Deere made wooden ploughs faced with steel, like other blacksmiths, but was not satisfied with them and studied and experimented to find the best curves and angles for a plough to be used in the soils around him. His ploughs were much in demand, and his need for steel led him to have larger and larger quantities produced for him, and the establishment which still bears his name grew to large proportions.

Another skilled blacksmith, (William Parlin), at Canton, Illinois, began making ploughs about 1842, which he loaded upon a wagon and peddled through the country. Later his establishment grew large. Another John Lane, a son of the first,

patented in 1868 a "soft-center" steel plough. The hard but brittle surface was backed by softer and more tenacious metal, to reduce the breakage. The same year (James Oliver,) a Scotch immigrant who had settled at South Bend, Indiana, received a patent for the "chilled plough." By an ingenious method the wearing surfaces of the casting were cooled more quickly than the back. The surfaces which came in contact with the soil had a hard, glassy surface, while the body of the plough was of tough iron. From small beginnings Oliver's establishment grew great, and the Oliver Chilled Plow Works at South Bend is today one of the largest and most favorably known privately owned industries in the United States.

From the single plough it was only a step to two or more ploughs fastened together, doing more work with approximately the same man power. The sulky plough, on which the ploughman rode, made his work easier, and gave him great control. Such ploughs were certainly in use as early as 1844, perhaps earlier. The next step forward was to substitute for horses a traction engine. Today one may see on thousands of farms a tractor pulling six, eight, ten, or more ploughs, doing the work better than it could be done by an individual ploughman.

On the "Bonanza" farms of the West a fifty horse-power engine draws sixteen ploughs, followed by harrows and a grain drill, and performs the three operations of ploughing, harrowing, and planting at the same time and covers fifty acres or more in a day.

The basic ideas in drills for small grains were successfully developed in Great Britain, and many British drills were sold in the United States before one was manufactured here. American manufacture of these drills began about 1840. Planters for corn came somewhat later. Machines to plant wheat successfully were unsuited to corn, which must be planted less profusely than wheat.

The American pioneers had only a sickle or a scythe with which to cut their grain. The addition to the scythe of wooden fingers, against which the grain might lie until the end of the swing, was a natural step, and seems to have been taken quite independently in several places, perhaps as early as 1803. Grain cradles are still used in hilly regions and in those parts of the country where little grain is grown.

The first attempts to build a machine to cut grain were made in England and Scotland, several of them in the eighteenth century; and in 1822

(Henry Ogle, a schoolmaster in Rennington, made a mechanical reaper, but the opposition of the laborers of the vicinity, who feared loss of employment, prevented further development. In 1826, Patrick Bell, a young Scotch student, afterward a Presbyterian minister, who had been moved by the fatigue of the harvesters upon his father's farm in Argyllshire, made an attempt to lighten their labor. His reaper was pushed by horses; a reel brought the grain against blades which opened and closed like scissors, and a traveling canvas apron deposited the grain at one side. The inventor received a prize from the Highland and Agricultural Society of Edinburgh, and pictures and full descriptions of his invention were published. Several models of this reaper were built in Great Britain, and it is said that four came to the United States; however this may be, Bell's machine was never generally adopted.

Soon afterward three men patented reapers in the United States: (William Manning, Plainfield, New Jersey, 1831; Obed Hussey, Cincinnati, Ohio, 1833; and Cyrus Hall McCormick, Staunton, Virginia, 1834.) Just how much they owed to Patrick Bell cannot be known, but it is probable that all had heard of his design if they had not seen his

drawings or the machine itself. The first of these inventors, Manning of New Jersey, drops out of the story, for it is not known whether he ever made a machine other than his model. More persistent was Obed Hussey of Cincinnati, who soon moved to Baltimore to fight out the issue with McCormick. Hussey was an excellent mechanic. He patented several improvements to his machine and received high praise for the efficiency of the work. But he was soon outstripped in the race because he was weak in the essential qualities which made McCormick the greatest figure in the world of agricultural machinery. McCormick was more than a mechanic; he was a man of vision; and he had the enthusiasm of a crusader and superb genius for business organization and advertisement. His story has been told in another volume of this series.¹

Though McCormick offered reapers for sale in 1834, he seems to have sold none in that year, nor any for six years afterwards. He sold two in 1840, seven in 1842, fifty in 1844. The machine was not really adapted to the hills of the Valley of Virginia, and farmers hesitated to buy a contrivance which needed the attention of a skilled mechanic. McCormick made a trip through the Middle West.

¹ *The Age of Big Business*, by Burton J. Hendrick.

In the rolling prairies, mile after mile of rich soil without a tree or a stone, he saw his future dominion. Hussey had moved East. McCormick did the opposite; he moved West, to Chicago, in 1847.

Chicago was then a town of hardly ten thousand, but McCormick foresaw its future, built a factory there, and manufactured five hundred machines for the harvest of 1848. From this time he went on from triumph to triumph. He formulated an elaborate business system. His machines were to be sold at a fixed price, payable in installments if desired, with a guarantee of satisfaction. He set up a system of agencies to give instruction or to supply spare parts. Advertising, chiefly by exhibitions and contests at fairs and other public gatherings, was another item of his programme. All would have failed, of course, if he had not built good machines, but he did build good machines, and was not daunted by the Government's refusal in 1848 to renew his original patent. He decided to make profits as a manufacturer rather than accept royalties as an inventor.

McCormick had many competitors, and some of them were in the field with improved devices ahead of him, but he always held his own, either by buying up the patent for a real improvement, or else

by requiring his staff to invent something to do the same work. Numerous new devices to improve the harvester were patented, but the most important was an automatic attachment to bind the sheaves with wire. This was patented in 1872, and McCormick soon made it his own. The harvester seemed complete. One man drove the team, and the machine cut the grain, bound it in sheaves, and deposited them upon the ground.

Presently, however, complaints were heard of the wire tie. When the wheat was threshed, bits of wire got into the straw, and were swallowed by the cattle; or else the bits of metal got among the wheat itself and gave out sparks in grinding, setting some mills on fire. Two inventors, almost simultaneously, produced the remedy. Marquis L. Gorham, working for McCormick, and John F. Appleby, whose invention was purchased by William Deering, one of McCormick's chief competitors, invented binders which used twine. By 1880 the self-binding harvester was complete. No distinctive improvement has been made since, except to add strength and simplification. The machine now needed the services of only two men, one to drive and the other to shock the bundles, and could reap twenty acres or more a day, tie the grain into

bundles of uniform size, and dump them in piles of five ready to be shocked.

Grain must be separated from the straw and chaff. The Biblical threshing floor, on which oxen or horses trampled out the grain, was still common in Washington's time, though it had been largely succeeded by the flail. In Great Britain several threshing machines were devised in the eighteenth century, but none was particularly successful. They were stationary, and it was necessary to bring the sheaves to them. The seventh patent issued by the United States, to Samuel Mulliken of Philadelphia, was for a threshing machine. The portable horse-power treadmill, invented in 1830 by (Hiram A. and John A. Pitts of Winthrop,) Maine, was presently coupled with a thresher, or "separator," and this outfit, with its men and horses, moving from farm to farm, soon became an autumn feature of every neighborhood. The treadmill was later on succeeded by the traction engine, and the apparatus now in common use is an engine which draws the greatly improved threshing machine from farm to farm, and when the destination is reached, furnishes the power to drive the thresher. Many of these engines are adapted to the use of straw as fuel.

Another development was the combination harvester and thresher used on the larger farms of the West. This machine does not cut the wheat close to the ground, but the cutter-bar, over twenty-five feet in length, takes off the heads. The wheat is separated from the chaff and automatically weighed into sacks, which are dumped as fast as two expert sewers can work. The motive power is a traction engine or else twenty to thirty horses, and seventy-five acres a day can be reaped and threshed. Often another tractor pulling a dozen wagons follows and the sacks are picked up and hauled to the granary or elevator.

Haying was once the hardest work on the farm, and in no crop has machinery been more efficient. The basic idea in the reaper, the cutter-bar, is the whole of the mower, and the machine developed with the reaper. Previously (Jeremiah Bailey, of Chester County, Pennsylvania, had patented in 1822 a machine drawn by horses carrying a revolving wheel with six scythes, which was widely used. The inventions of Manning, Hussey, and McCormick made the mower practicable. (Hazard Knowles, an employee of the Patent Office, invented the hinged cutter-bar, which could be lifted over an obstruction, but never patented

the invention. / William F. Ketchum/ of Buffalo, New York, in 1844, patented the first machine intended to cut hay only, and dozens of others followed. The modern mowing machine was practically developed in the patent of Lewis Miller of Canton, Ohio, in 1858. Several times as many mowers as harvesters are sold, and for that matter, reapers without binding attachments are still manufactured.

Hayrakes and tedders seem to have developed almost of themselves. Diligent research has failed to discover any reliable information on the invention of the hayrake, though a horserake was patented as early as 1818. Joab Center of Hudson, New York, patented a machine for turning and spreading hay in 1834. Mechanical hay-loaders have greatly reduced the amount of human labor. The hay-press makes storage and transportation easier and cheaper.

There are binders which cut and bind corn. An addition shocks the corn and deposits it upon the ground. The shredder and husker removes the ears, husks them, and shreds shucks, stalks, and fodder. Power shellers separate grain and cobs more than a hundred times as rapidly as a pair of human hands could do. One student of agriculture

has estimated that it would require the whole agricultural population of the United States one hundred days to shell the average corn crop by hand, but this is an exaggeration.

The list of labor-saving machinery in agriculture is by no means exhausted. There are clover hullers, bean and pea threshers, ensilage cutters, manure spreaders, and dozens of others. On the dairy farm the cream separator both increases the quantity and improves the quality of the butter and saves time. Power also drives the churns. On many farms cows are milked and sheep are sheared by machines and eggs are hatched without hens.

There are, of course, thousands of farms in the country where machinery cannot be used to advantage and where the work is still done entirely or in part in the old ways.

Historians once were fond of marking off the story of the earth and of men upon the earth into distinct periods fixed by definite dates. One who attempts to look beneath the surface cannot accept this easy method of treatment. Beneath the surface new tendencies develop long before they demand recognition; an institution may be decaying long before its weakness is apparent. The

American Revolution began not with the Stamp Act but at least a century earlier, as soon as the settlers realized that there were three thousand miles of sea between England and the rude country in which they found themselves; the Civil War began, if not in early Virginia, with the "Dutch Man of Warre that sold us twenty Negars," at least with (Eli Whitney and his cotton gin).

Nevertheless, certain dates or short periods seem to be flowering times. Apparently all at once a flood of invention, a change of methods, a difference in organization, or a new psychology manifests itself. And the decade of the Civil War does serve as a landmark to mark the passing of one period in American life and the beginning of another; especially in agriculture; and as agriculture is the basic industry of the country it follows that with its mutations the whole superstructure is also changed.

The United States which fought the Civil War was vastly different from the United States which fronted the world at the close of the Revolution. The scant four million people of 1790 had grown to thirty-one and a half million. This growth had come chiefly by natural increase, but also by immigration, conquest, and annexation. Settlement

had reached the Pacific Ocean, though there were great stretches of almost uninhabited territory between the settlements on the Pacific and those just beyond the Mississippi.

The cotton gin had turned the whole South toward the cultivation of cotton, though some States were better fitted for mixed farming, and their devotion to cotton meant loss in the end as subsequent events have proved. The South was not manufacturing any considerable proportion of the cotton it grew, but the textile industry was flourishing in New England. A whole series of machines similar to those used in Great Britain, but not identical, had been invented in America. American mills paid higher wages than British and in quantity production were far ahead of the British mills, in proportion to hands employed, which meant being ahead of the rest of the world.

Wages in America, measured by the world standard, were high, though as expressed in money, they seem low now. They were conditioned by the supply of free land, or land that was practically free. The wages paid were necessarily high enough to attract laborers from the soil which they might easily own if they chose. There was no fixed laboring class. The boy or girl in a textile mill often

worked only a few years to save money, buy a farm, or to enter some business or profession.

The steamboat) now, wherever there was navigable water, and the railroad, for a large part of the way, offered transportation to the boundless West. Steamboats traversed all the larger rivers and the lakes. The railroad was growing rapidly. Its lines had extended to more than thirty thousand miles. Construction went on during the war, and the transcontinental railway was in sight. The locomotive had approached standardization, and the American railway car was in form similar to that of the present day, though not so large, so comfortable, or so strong. (The Pullman car, from which has developed the chair car, the dining car, and the whole list of special cars, was in process of development, and the automatic air brake of) George Westinghouse) was soon to follow.

Thus far had the nation progressed in invention and industry along the lines of peaceful development. But with the Civil War came a sudden and tremendous advance. No result of the Civil War, political or social, has more profoundly affected American life than the application to the farm, as a war necessity, of machinery on a great scale. So long as labor was plentiful and cheap, only a

comparatively few farmers could be interested in expensive machinery, but when the war called the young men away the worried farmers gladly turned to the new machines and found that they were able not only to feed the Union, but also to export immense quantities of wheat to Europe, even during the war. Suddenly the West leaped into great prosperity. And long centuries of economic and social development were spanned within a few decades.

CHAPTER VI

AGENTS OF COMMUNICATION

COMMUNICATION is one of man's primal needs. There was indeed a time when no formula of language existed, when men communicated with each other by means of gestures, grimaces, guttural sounds, or rude images of things seen; but it is impossible to conceive of a time when men had no means of communication at all. And at last, after long ages, men evolved in sound the names of the things they knew and the forms of speech; ages later, the alphabet and the art of writing; ages later still, those wonderful instruments of extension for the written and spoken word: the telegraph, the telephone, the modern printing press, the phonograph, the typewriter, and the camera.

The word "telegraph" is derived from Greek and means "to write far"; so it is a very exact word, for to write far is precisely what we do when we

send a telegram. The word today, used as a noun, denotes the system of wires with stations and operators and messengers, girdling the earth and reaching into every civilized community, whereby news is carried swiftly by electricity. But the word was coined long before it was discovered that intelligence could be communicated by electricity. It denoted at first a system of semaphores, or tall poles with movable arms, and other signaling apparatus, set within sight of one another. There was such a telegraph line between Dover and London at the time of Waterloo; and this telegraph began relating the news of the battle, which had come to Dover by ship, to anxious London, when a fog set in and the Londoners had to wait until a courier on horseback arrived. And, in the very years when the real telegraph was coming into being, the United States Government, without a thought of electricity, was considering the advisability of setting up such a system of telegraphs in the United States.

The telegraph is one of America's gifts to the world. The honor for this invention falls to Samuel Finley Breese Morse, a New Englander of old Puritan stock. Nor is the glory that belongs to Morse in any way dimmed by the fact that he made

use of the discoveries of other men who had been trying to unlock the secrets of electricity ever since Franklin's experiments. If Morse discovered no new principle, he is nevertheless the man of all the workers in electricity between his own day and Franklin's whom the world most delights to honor; and rightly so, for it is to such as Morse that the world is most indebted. Others knew; Morse saw and acted. Others had found out the facts, but Morse was the first to perceive the practical significance of those facts; the first to take steps to make them of service to his fellows; the first man of them all with the pluck and persistence to remain steadfast to his great design, through twelve long years of toil and privation, until his countrymen accepted his work and found it well done.

Morse was happy in his birth and early training. He was born in 1791, at Charlestown, Massachusetts. His father was a Congregational minister and a scholar of high standing, who, by careful management, was able to send his three sons to Yale College. Thither went young Samuel (or Finley, as he was called by his family) at the age of fourteen and came under the influence of Benjamin Silliman, Professor of Chemistry, and of Jeremiah Day, Professor of Natural Philosophy,

afterwards President of Yale College, whose teaching gave him impulses which in later years led to the invention of the telegraph. "Mr. Day's lectures are very interesting," the young student wrote home in 1809; "they are upon electricity; he has given us some very fine experiments, the whole class taking hold of hands form the circuit of communication and we all receive the shock apparently at the same moment." Electricity, however, was only an alluring study. It afforded no means of livelihood, and Morse had gifts as an artist; in fact, he earned a part of his college expenses painting miniatures at five dollars apiece. He decided, therefore, that art should be his vocation.

A letter written years afterwards by Joseph M. Dulles of Philadelphia, who was at New Haven preparing for Yale when Morse was in his senior year, is worth reading here:

I first became acquainted with him at New Haven, when about to graduate with the class of 1810, and had such an association as a boy preparing for college might have with a senior who was just finishing his course. Having come to New Haven under the care of Rev. Jedidiah Morse, the venerable father of the three Morses, all distinguished men, I was commended to the protection of Finley, as he was then commonly designated, and therefore saw him frequently

during the brief period we were together. The father I regard as the gravest man I ever knew. He was a fine exemplar of the gentler type of the Puritan, courteous in manner, but stern in conduct and in aspect. He was a man of conflict, and a leader in the theological contests in New England in the early part of this century. Finley, on the contrary, bore the expression of gentleness entirely. In person rather above the ordinary height, well formed, graceful in demeanor, with a complexion, if I remember right, slightly ruddy, features duly proportioned, and often lightened with a genial and expressive smile. He was, altogether, a handsome young man, with manners unusually bland. It is needless to add that with intelligence, high culture, and general information, and with a strong bent to the fine arts, Mr. Morse was in 1810 an attractive young man. During the last year of his college life he occupied his leisure hours, with a view to his self-support, in taking the likenesses of his fellow-students on ivory, and no doubt with success, as he obtained afterward a very respectable rank as a portrait-painter. Many pieces of his skill were afterward executed in Charleston, South Carolina.¹

That Morse was destined to be a painter seemed certain, and when, soon after graduating from Yale, he made the acquaintance of Washington Allston, an American artist of high standing, any doubts that may have existed in his mind as to his vocation were set at rest. Allston was then living

¹ Prime, *The Life of Samuel F. B. Morse, LL.D.*, p. 26.

in Boston, but was planning to return to England, where his name was well known, and it was arranged that young Morse should accompany him as his pupil. So in 1811 Morse went to England with Allston and returned to America four years later an accredited portrait painter, having studied not only under Allston but under the famous master, Benjamin West, and having met on intimate terms some of the great Englishmen of the time. He opened a studio in Boston, but as sitters were few, he made a trip through New England, taking commissions for portraits, and also visited Charleston, South Carolina, where some of his paintings may be seen today.

At Concord, New Hampshire, Morse met Miss Lucretia Walker, a beautiful and cultivated young woman, and they were married in 1818. Morse then settled in New York. His reputation as a painter increased steadily, though he gained little money, and in 1825 he was in Washington painting a portrait of the Marquis La Fayette, for the city of New York, when he heard from his father the bitter news of his wife's death in New Haven, then a journey of seven days from Washington. Leaving the portrait of La Fayette unfinished, the heartbroken artist made his way home.

Two years afterwards Morse was again obsessed with the marvels of electricity, as he had been in college. The occasion this time was a series of lectures on that subject given by James Freeman Dana before the New York Athenæum in the chapel of Columbia College. Morse attended these lectures and formed with Dana an intimate acquaintance. Dana was in the habit of going to Morse's studio, where the two men would talk earnestly for long hours. But Morse was still devoted to his art; besides, he had himself and three children to support, and painting was his only source of income.

Back to Europe went Morse in 1829 to pursue his profession and perfect himself in it by three years' further study. Then came the crisis. Homeward bound on the ship *Sully* in the autumn of 1832, Morse fell into conversation with some scientific men who were on board. One of the passengers asked this question: "Is the velocity of electricity reduced by the length of its conducting wire?" To which his neighbor replied that electricity passes instantly over any known length of wire and referred to Franklin's experiments with several miles of wire, in which no appreciable time elapsed between a touch at one end and a spark at the other.

Here was a fact already well known. Morse must have known it himself. But the tremendous significance of that fact had never before occurred to him nor, so far as he knew, to any man. A recording telegraph! Why not? Intelligence delivered at one end of a wire instantly recorded at the other end, no matter how long the wire! It might reach across the continent or even round the earth. The idea set his mind on fire.

Home again in November, 1832, Morse found himself on the horns of a dilemma. To give up his profession meant that he would have no income; on the other hand, how could he continue wholeheartedly painting pictures while consumed with the idea of the telegraph? The idea would not down; yet he must live; and there were his three motherless children in New Haven. He would have to go on painting as well as he could and develop his telegraph in what time he could spare. His brothers, Richard and Sidney, were both living in New York and they did what they could for him, giving him a room in a building they had erected at Nassau and Beekman Streets. Morse's lot at this time was made all the harder by hopes raised and dashed to earth again. Congress had voted money for mural paintings for the rotunda of

the Capitol. The artists were to be selected by a committee of which John Quincy Adams was chairman. Morse expected a commission for a part of the work, for his standing at that time was second to that of no American artist, save Allston, and Allston he knew had declined to paint any of the pictures and had spoken in his favor. Adams, however, as chairman of the committee was of the opinion that the pictures should be done by foreign artists, there being no Americans available, he thought, of sufficiently high standing to execute the work with fitting distinction. This opinion, publicly expressed, infuriated James Fenimore Cooper, Morse's friend, and Cooper wrote an attack on Adams in the New York *Evening Post*, but without signing it. Supposing Morse to be the author of this article, Adams summarily struck his name from the list of artists who were to be employed.

How very poor Morse was about this time is indicated by a story afterwards told by General Strother of Virginia, who was one of his pupils:

I engaged to become Morse's pupil and subsequently went to New York and found him in a room in University Place. He had three or four other pupils and I soon found that our professor had very little patronage.

I paid my fifty dollars for one-quarter's instruction. Morse was a faithful teacher and took as much interest in our progress as — more indeed than — we did ourselves. But he was very poor. I remember that, when my second quarter's pay was due, my remittance did not come as expected, and one day the professor came in and said, courteously: "Well Strother, my boy, how are we off for money?"

"Why professor," I answered, "I am sorry to say that I have been disappointed, but I expect a remittance next week."

"Next week," he repeated sadly, "I shall be dead by that time."

"Dead, sir?"

"Yes, dead by starvation."

I was distressed and astonished. I said hurriedly:

"Would ten dollars be of any service?"

"Ten dollars would save my life. That is all it would do."

I paid the money, all that I had, and we dined together. It was a modest meal, but good, and after he had finished, he said:

"This is my first meal for twenty-four hours. Strother, don't be an artist. It means beggary. Your life depends upon people who know nothing of your art and care nothing for you. A house dog lives better, and the very sensitiveness that stimulates an artist to work keeps him alive to suffering."¹

In 1835 Morse received an appointment to the teaching staff of New York University and moved

¹ Prime, p. 424.

his workshop to a room in the University building in Washington Square. "There," says his biographer,¹ "he wrought through the year 1836, probably the darkest and longest year of his life, giving lessons to pupils in the art of painting while his mind was in the throes of the great invention." In that year he took into his confidence one of his colleagues in the University, Leonard D. Gale, who assisted him greatly in improving the apparatus, while the inventor himself formulated the rudiments of the telegraphic alphabet, or Morse Code, as it is known today. At length all was ready for a test and the message flashed from transmitter to receiver. The telegraph was born, though only an infant as yet. "Yes, that room of the University was the birthplace of the Recording Telegraph," said Morse years later. On September 2, 1837, a successful experiment was made with seventeen hundred feet of copper wire coiled around the room, in the presence of Alfred Vail, a student, whose family owned the Speedwell Iron Works, at Morristown, New Jersey, and who at once took an interest in the invention and persuaded his father, Judge Stephen Vail, to advance money for experiments. Morse filed a petition for

¹ Prime, p. 311.

a patent in October and admitted his colleague Gale, as well as Alfred Vail, to partnership. Experiments followed at the Vail shops, all the partners working day and night in their enthusiasm. The apparatus was then brought to New York and gentlemen of the city were invited to the University to see it work before it left for Washington. The visitors were requested to write dispatches, and the words were sent round a three-mile coil of wire and read at the other end of the room by one who had no prior knowledge of the message.

In February, 1838, Morse set out for Washington with his apparatus, and stopped at Philadelphia on the invitation of the Franklin Institute to give a demonstration to a committee of that body. Arrived at Washington, he presented to Congress a petition, asking for an appropriation to enable him to build an experimental line. The question of the appropriation was referred to the Committee on Commerce, who reported favorably, and Morse then returned to New York to prepare to go abroad, as it was necessary for his rights that his invention should be patented in European countries before publication in the United States.

Morse sailed in May, 1838, and returned to New York by the steamship *Great Western* in April,

1839. His journey had not been very successful. He had found London in the excitement of the ceremonies of the coronation of Queen Victoria, and the British Attorney-General had refused him a patent on the ground that American newspapers had published his invention, making it public property. In France he had done better. But the most interesting result of the journey was something not related to the telegraph at all. In Paris he had met Daguerre, the celebrated Frenchman who had discovered a process of making pictures by sunlight, and Daguerre had given Morse the secret. This led to the first pictures taken by sunlight in the United States and to the first photographs of the human face taken anywhere. Daguerre had never attempted to photograph living objects and did not think it could be done, as rigidity of position was required for a long exposure. Morse, however, and his associate, John W. Draper, were very soon taking portraits successfully.

Meanwhile the affairs of the telegraph at Washington had not prospered. Congress had done nothing towards the grant which Morse had requested, notwithstanding the favorable report of its committee, and Morse was in desperate straits for money even to live on. He appealed to the Vails

to assist him further, but they could not, since the panic of 1837 had impaired their resources. He earned small sums from his daguerreotypes and his teaching.

By December, 1842, Morse was in funds again; sufficiently, at least, to enable him to go to Washington for another appeal to Congress. And at last, on February 23, 1843, a bill appropriating thirty thousand dollars to lay the wires between Washington and Baltimore passed the House by a majority of six. Trembling with anxiety, Morse sat in the gallery of the House while the vote was taken and listened to the irreverent badinage of Congressmen as they discussed his bill. One member proposed an amendment to set aside half the amount for experiments in mesmerism, another suggested that the Millerites should have a part of the money, and so on; however, they passed the bill. And that night Morse wrote: "The long agony is over."

But the agony was not over. The bill had yet to pass the Senate. The last day of the expiring session of Congress arrived, March 3, 1843, and the Senate had not reached the bill. Says Morse's biographer:

In the gallery of the Senate Professor Morse had sat all the last day and evening of the session. At midnight

the session would close. Assured by his friends that there was no possibility of the bill being reached, he left the Capitol and retired to his room at the hotel, dispirited, and well-nigh broken-hearted. As he came down to breakfast the next morning, a young lady entered, and, coming toward him with a smile, exclaimed:

“I have come to congratulate you!”

“For what, my dear friend?” asked the professor, of the young lady, who was Miss Annie G. Ellsworth, daughter of his friend the Commissioner of Patents.

“On the passage of your bill.”

The professor assured her it was not possible, as he remained in the Senate-Chamber until nearly midnight, and it was not reached. She then informed him that her father was present until the close, and, in the last moments of the session, the bill was passed without debate or revision. Professor Morse was overcome by the intelligence, so joyful and unexpected, and gave at the moment to his young friend, the bearer of these good tidings, the promise that she should send the first message over the first line of telegraph that was opened.¹

Morse and his partners² then proceeded to the construction of the forty-mile line of wire between Baltimore and Washington. At this point Ezra Cornell, afterwards a famous builder of telegraphs

¹ Prime, p. 465.

² The property in the invention was divided into sixteen shares (the partnership having been formed in 1838) of which Morse held 9, Francis O. J. Smith 4, Alfred Vail 2, Leonard D. Gale 1. In patents to be obtained in foreign countries, Morse was to hold 8

and founder of Cornell University, first appears in history as a young man of thirty-six. Cornell invented a machine to lay pipe underground to contain the wires and he was employed to carry out the work of construction. The work was commenced at Baltimore and was continued until experiment proved that the underground method would not do, and it was decided to string the wires on poles. Much time had been lost, but once the system of poles was adopted the work progressed rapidly, and by May, 1844, the line was completed. On the twenty-fourth of that month Morse sat before his instrument in the room of the Supreme Court at Washington. His friend Miss Ellsworth handed him the message which she had chosen: "*What hath God wrought!*" Morse flashed it to Vail forty miles away in Baltimore, and Vail instantly flashed back the same momentous words, "*What hath God wrought!*"

Two days later the Democratic National Convention met in Baltimore to nominate a President and Vice-President. The leaders of the Convention

shares, Smith 5, Vail 2, Gale 1. Smith had been a member of Congress and Chairman of the Committee on Commerce. He was admitted to the partnership in consideration of his assisting Morse to arouse the interest of European Governments.

desired to nominate Senator Silas Wright of New York, who was then in Washington, as running mate to James K. Polk, but they must know first whether Wright would consent to run as Vice-President. So they posted a messenger off to Washington but were persuaded at the same time to allow the new telegraph to try what it could do. The telegraph carried the offer to Wright and carried back to the Convention Wright's refusal of the honor. The delegates, however, would not believe the telegraph, until their own messenger, returning the next day, confirmed its message.

For a time the telegraph attracted little attention. But Cornell stretched the lines across the country, connecting city with city, and Morse and Vail improved the details of the mechanism and perfected the code. Others came after them and added further improvements. And it is gratifying to know that both Morse and Vail, as well as Cornell, lived to reap some return for their labor. Morse lived to see his telegraph span the continent, and link the New World with the Old, and died in 1872 full of honors.

Prompt communication of the written or spoken message is a demand even more insistent than

prompt transportation of men and goods. By 1859 both the railroad and the telegraph had reached the old town of St. Joseph on the Missouri. Two thousand miles beyond, on the other side of plains and mountains and great rivers, lay prosperous California. The only transportation to California was by stage-coach, a sixty days' journey, or else across Panama, or else round the Horn, a choice of three evils. But to establish quicker communication, even though transportation might lag, the men of St. Joseph organized the Pony Express, to cover the great wild distance by riders on horseback, in ten or twelve days. Relay stations for the horses and men were set up at appropriate points all along the way, and a post-boy dashed off from St. Joseph every twenty-four hours, on arrival of the train from the East. And for a time the Pony Express did its work and did it well. President Lincoln's First Inaugural was carried to California by the Pony Express; so was the news of the firing on Fort Sumter. But by 1862 the Pony Express was quietly superseded by the telegraph, which in that year had completed its circuits all the way to San Francisco, seven years ahead of the first transcontinental railroad. And in four more years Cyrus W. Field and Peter

Cooper had carried to complete success the Atlantic Cable; and the Morse telegraph was sending intelligence across the sea, as well as from New York to the Golden Gate.

And today ships at sea and stations on land, separated by the sea, speak to one another in the language of the Morse Code, without the use of wires. Wireless, or radio, telegraphy was the invention of a nineteen-year-old boy, Guglielmo Marconi, an Italian; but it has been greatly extended and developed at the hands of four Americans: Fessenden, Alexanderson, Langmuir, and Lee De Forest. It was De Forest's invention that made possible transcontinental and transatlantic telephone service, both with and without wires.

The story of the telegraph's younger brother, and great ally in communication, the telephone of Alexander Graham Bell, is another pregnant romance of American invention. But that is a story by itself, and it begins in a later period and so falls within the scope of another volume of these Chronicles.¹

Wise newspapermen stiffened to attention when the telegraph began ticking. The *New York Herald*,

¹ *The Age of Big Business*, by Burton J. Hendrick, *The Chronicles of America*, vol. XXXIX.

the *Sun*, and the *Tribune* had been founded only recently and they represented a new type of journalism, swift, fearless, and energetic. The proprietors of these newspapers saw that this new instrument was bound to affect all newspaperdom profoundly. How was the newspaper to cope with the situation and make use of the news that was coming in and would be coming in more and more over the wires?

For one thing, the newspapers needed better printing machinery. The application of steam, or any mechanical power, to printing in America was only begun. It had been introduced by Robert Hoe in the very years when Morse was struggling to perfect the telegraph. Before that time newspapers were printed in the United States, on presses operated as Franklin's press had been operated, by hand. The New York *Sun*, the pioneer of cheap modern newspapers, was printed by hand in 1833, and four hundred impressions an hour was the highest speed of one press. There had been, it is true, some improvements over Franklin's printing press. The Columbian press of George Clymer of Philadelphia, invented in 1816, was a step forward. The Washington press, patented in 1829 by Samuel Rust of New York, was another step forward.

Then had come Robert Hoe's double-cylinder, steam-driven printing press. But a swifter machine was wanted. And so in 1845 Richard March Hoe, a son of Robert Hoe, invented the revolving or rotary press, on the principle of which larger and larger machines have been built — machines so complex and wonderful that they baffle description; which take in reels of white paper and turn out great newspapers complete, folded and counted, at the rate of a hundred thousand copies an hour. American printing machines are in use today the world over. The London *Times* is printed on American machines.

Hundreds of new inventions and improvements on old inventions followed hard on the growth of the newspaper, until it seemed that the last word had been spoken. The newspapers had the wonderful Hoe presses; they had cheap paper; they had excellent type, cast by machinery; they had a satisfactory process of multiplying forms of type by stereotyping; and at length came a new process of making pictures by photo-engraving, supplanting the old-fashioned process of engraving on wood. Meanwhile, however, in one important department of the work, the newspapers had made no advance whatever. The newspapers of New York in the

year 1885, and later, set up their type by the same method that Benjamin Franklin used to set up the type for *The Pennsylvania Gazette*. The compositor stood or sat at his "case," with his "copy" before him, and picked the type up letter by letter until he had filled and correctly spaced a line. Then he would set another line, and so on, all with his hands. After the job was completed, the type had to be distributed again, letter by letter. Typesetting was slow and expensive.

This labor of typesetting was at last generally done away with by the invention of two intricate and ingenious machines. The linotype, the invention of Ottmar Mergenthaler of Baltimore, came first; then the monotype of Tolbert Lanston, a native of Ohio. The linotype is the favorite composing machine for newspapers and is also widely used in typesetting for books, though the monotype is preferred by book printers. One or other of these machines has today replaced, for the most part, the old hand compositors in every large printing establishment in the United States.

While the machinery of the great newspapers was being developed, another instrument of communication, more humble but hardly less important

in modern life, was coming into existence. The typewriter is today in every business office and is another of America's gifts to the commercial world. One might attempt to trace the typewriter back to the early seals, or to the name plates of the Middle Ages, or to the records of the British Patent Office, for 1714, which mention a machine for embossing. But it would be difficult to establish the identity of these contrivances with the modern typewriter.

Two American devices, one of William Burt in 1829, for a "typographer," and another of Charles Thurber, of Worcester, Massachusetts, in 1843, may also be passed over. Alfred Ely Beach made a model for a typewriter as early as 1847, but neglected it for other things, and his next effort in printing machines was a device for embossing letters for the blind. His typewriter had many of the features of the modern typewriter, but lacked a satisfactory method of inking the types. This was furnished by S. W. Francis of New York, whose machine, in 1857, bore a ribbon saturated with ink. None of these machines, however, was a commercial success. They were regarded merely as the toys of ingenious men.

The accredited father of the typewriter was

a Wisconsin newspaperman, Christopher Latham Sholes, editor, politician, and anti-slavery agitator. A strike of his printers led him to unsuccessful attempts to invent a typesetting machine. He did succeed, however, in making, in collaboration with another printer, Samuel W. Soule, a numbering machine, and a friend, Carlos Glidden, to whom this ingenious contrivance was shown, suggested a machine to print letters.

The three friends decided to try. None had studied the efforts of previous experimenters, and they made many errors which might have been avoided. Gradually, however, the invention took form. Patents were obtained in June, 1868, and again in July of the same year, but the machine was neither strong nor trustworthy. Now appeared James Densmore and bought a share in the machine, while Soule and Glidden retired. Densmore furnished the funds to build about thirty models in succession, each a little better than the preceding. The improved machine was patented in 1871, and the partners felt that they were ready to begin manufacturing.

Wisely they determined, in 1873, to offer their machine to Eliphalet Remington and Sons, then manufacturing firearms, sewing machines, and the

like, at Ilion, New York. Here, in well-equipped machine shops it was tested, strengthened, and improved. The Remingtons believed they saw a demand for the machine and offered to buy the patents, paying either a lump sum, or a royalty. It is said that Sholes preferred the ready cash and received twelve thousand dollars, while Densmore chose the royalty and received a million and a half.

The telegraph, the press, and the typewriter are agents of communication for the written word. The telephone is an agent for the spoken word. And there is another instrument for recording sound and reproducing it, which should not be forgotten. It was in 1877 that Thomas Alva Edison completed the first phonograph. The air vibrations set up by the human voice were utilized to make minute indentations on a sheet of tinfoil placed over a metallic cylinder, and the machine would then reproduce the sounds which had caused the indentations. The record wore out after a few reproductions, however, and Edison was too busy to develop his idea further for a time, though later he returned to it.

The phonograph today appears under various names, but by whatever name they are called, the best machines reproduce with wonderful fidelity the

human voice, in speech or song, and the tones of either a single instrument or a whole orchestra. The most distinguished musicians are glad to do their best for the preservation and reproduction of their art, and through these machines, good music is brought to thousands to whom it could come in no other way.

The camera bears a large part in the diffusion of intelligence, and the last half century in the United States has seen a great development in photography and photo-engraving. The earliest experiments in photography belong almost exclusively to Europe. Morse, as we have seen, introduced the secret to America and interested his friend John W. Draper, who had a part in the perfection of the dry plate and who was one of the first, if not the first, to take a portrait by photography.

The world's greatest inventor in photography is, however, George Eastman, of Rochester. It was in 1888 that Eastman introduced a new camera, which he called by the distinctive name Kodak, and with it the slogan: "You press the button, we do the rest." This first kodak was loaded with a roll of sensitized paper long enough for a hundred exposures. Sent to the makers, the roll could itself

be developed and pictures could be printed from it. Eastman had been an amateur photographer when the fancy was both expensive and tedious. Inventing a method of making dry plates, he began to manufacture them in a small way as early as 1880. After the first kodak, there came others filled with rolls of sensitized nitro-cellulose film. Priority in the invention of the cellulose film, instead of glass, which has revolutionized photography, has been decided by the courts to belong to the Reverend Hannibal Goodwin, but the honor none the less belongs to Eastman, who independently worked out his process and gave photography to the millions. The introduction by the Eastman Kodak Company of a film cartridge which could be inserted or removed without retiring to a dark room removed the chief difficulty in the way of amateurs, and a camera of some sort, varying in price from a dollar or two to as many hundreds, is today an indispensable part of a vacation equipment.

In the development of the animated pictures Thomas Alva Edison has played a large part. Many were the efforts to give the appearance of movement to pictures before the first real entertainment was staged by Henry Heyl of Philadelphia. Heyl's

pictures were on glass plates fixed in the circumference of a wheel, and each was brought and held for a part of a second before the lens. This method was obviously too slow and too expensive. Edison with his keen mind approached the difficulty and after a prolonged series of experiments arrived at the decision that a continuous tape-like film would be necessary. He invented the first practical "taking" camera and evoked the enthusiastic coöperation of George Eastman in the production of this tape-like film, and the modern motion picture was born. The projecting machine was substantially like the "taking" camera and was so used. Other inventors, such as Paul in England and Lumière in France, produced other types of projecting machines, which differed only in mechanical details.

When the motion picture was taken up in earnest in the United States, the world stared in astonishment at the apparent recklessness of the early managers. The public responded, however, and there is hardly a hamlet in the nation where there is not at least one moving-picture house. The most popular actors have been drawn from the speaking stage into the "movies," and many new actors have been developed. In the small town, the picture theater is often a converted storeroom, but

in the cities, some of the largest and most attractive theaters have been given over to the pictures, and others even more luxurious have been specially built. The Eastman Company alone manufactures about ten thousand miles of film every month.

Besides affording amusement to millions, the moving picture has been turned to instruction. Important news events are shown on the screen, and historical events are preserved for posterity by depositing the films in a vault. What would the historical student not give for a film faithfully portraying the inauguration of George Washington! The motion picture has become an important factor in instruction in history and science in the schools and this development is still in its infancy.

CHAPTER VII

THE STORY OF RUBBER

ONE day in 1852, at Trenton, New Jersey, there appeared in the Circuit Court of the United States two men, the legal giants of their day, to argue the case of *Goodyear vs. Day* for infringement of patent. Rufus Choate represented the defendant and Daniel Webster the plaintiff. Webster, in the course of his plea, one of the most brilliant and moving ever uttered by him, paused for a moment, drew from himself the attention of those who were hanging upon his words, and pointed to his client. He would have them look at the man whose cause he pleaded: a man of fifty-two, who looked fifteen years older, sallow, emaciated from disease, due to long privations, bitter disappointments, and wrongs. This was Charles Goodyear, inventor of the process which put rubber into the service of the world. Said Webster:

And now is Charles Goodyear the discoverer of this invention of vulcanized rubber? Is he the first man upon

whose mind the idea ever flashed, or to whose intelligence the fact ever was disclosed, that by carrying heat to a certain height it would cease to render plastic the India Rubber and begin to harden and metallize it? Is there a man in the world who found out that fact before Charles Goodyear? Who is he? Where is he? On what continent does he live? Who has heard of him? What books treat of him? What man among all the men on earth has seen him, known him, or named him? Yet it is certain that this discovery has been made. It is certain that it exists. It is certain that it is now a matter of common knowledge all over the civilized world. It is certain that ten or twelve years ago it was not knowledge. It is certain that this curious result has grown into knowledge by somebody's discovery and invention. And who is that somebody? The question was put to my learned opponent by my learned associate. If Charles Goodyear did not make this discovery, who did make it? Who did make it? Why, if our learned opponent had said he should endeavor to prove that some one other than Mr. Goodyear had made this discovery, that would have been very fair. I think the learned gentleman was very wise in not doing so. For I have thought often, in the course of my practice in law, that it was not very advisable to raise a spirit that one could not conveniently lay again. Now who made this discovery? And would it not be proper? I am sure it would. And would it not be manly? I am sure it would. Would not my learned friend and his coadjutor have acted a more noble part, if they had stood up and said that this invention was not Goodyear's, but it was an invention of such and such a man, in this or that country? On the

contrary they do not meet Goodyear's claim by setting up a distinct claim of anybody else. They attempt to prove that he was not the inventor by little shreds and patches of testimony. Here a little bit of sulphur, and there a little parcel of lead; here a little degree of heat, a little hotter than would warm a man's hands, and in which a man could live for ten minutes or a quarter of an hour; and yet they never seem to come to the point. I think it is because their materials did not allow them to come to the manly assertion that somebody else did make this invention, giving to that somebody a local habitation and a name. We want to know the name, and the habitation, and the location of the man upon the face of this globe, who invented vulcanized rubber, if it be not he, who now sits before us.

Well there are birds which fly in the air, seldom lighting, but often hovering. Now I think this is a question not to be hovered over, not to be brooded over, and not to be dealt with as an infinitesimal quantity of small things. It is a case calling for a manly admission and a manly defense. I ask again, if there is anybody else than Goodyear who made this invention, who is he? Is the discovery so plain that it might have come about by accident? It is likely to work important changes in the arts everywhere. *It introduces quite a new material into the manufacture of the arts, that material being nothing less than ELASTIC METAL.* It is hard like metal and as elastic as pure original gum elastic. Why, that is as great and momentous a phenomenon occurring to men in the progress of their knowledge, as it would be for a man to show that iron and gold could remain iron and gold and yet become elastic

like India Rubber. It would be just such another result. Now, this fact cannot be denied; it cannot be secreted; it cannot be kept out of sight; somebody has made this invention. That is certain. Who is he? Mr. Hancock has been referred to. But he expressly acknowledges Goodyear to be the first inventor. I say that there is not in the world a human being that can stand up and say that it is his invention, except the man who is sitting at that table.

The court found for the plaintiff, and this decision established for all time the claim of the American, Charles Goodyear, to be the sole inventor of vulcanized rubber.

This trial may be said to be the dramatic climax in the story of rubber. It celebrated the hour when the science of invention turned a raw product—which had tantalized by its promise and wrought ruin by its treachery—into a manufacture adaptable to a thousand uses, adding to man's ease and health and to the locomotion, construction, and communication of modern life.

When Columbus revisited Hayti on his second voyage, he observed some natives playing with a ball. Now, ball games are the oldest sport known. From the beginning of his history man, like the kitten and the puppy, has delighted to play with the round thing that rolls. The men who came

with Columbus to conquer the Indies had brought their Castilian wind-balls to play with in idle hours. But at once they found that the balls of Hayti were incomparably superior toys; they bounced better. These high bouncing balls were made, so they learned, from a milky fluid of the consistency of honey which the natives procured by tapping certain trees and then cured over the smoke of palm nuts. A discovery which improved the delights of ball games was noteworthy.

The old Spanish historian, Herrera, gravely transcribed in his pages all that the governors of Hayti reported about the bouncing balls. Some fifty years later another Spanish historian related that the natives of the Amazon valley made shoes of this gum; and that Spanish soldiers spread their cloaks with it to keep out the rain. Many years later still, in 1736, a French astronomer, who was sent by his government to Peru to measure an arc of the meridian, brought home samples of the gum and reported that the natives make lights of it, "which burn without a wick and are very bright," and "shoes of it which are waterproof, and when smoked they have the appearance of leather. They also make pear-shaped bottles on the necks of which they fasten wooden tubes. Pressure on the

bottle sends the liquid squirting out of the tube, so they resemble syringes." Their name for the fluid, he added, was "cachuchu" — caoutchouc, we now write it. Evidently the samples filled no important need at the time, for we hear no more of the gum until thirty-four years afterward. Then, so an English writer tells us, a use was found for the gum — and a name. A stationer accidentally discovered that it would erase pencil marks, And, as it came from the Indies and rubbed, of course it was "India rubber."

About the year 1820 American merchantmen, plying between Brazil and New England, sometimes carried rubber as ballast on the home voyage and dumped it on the wharves at Boston. One of the shipmasters exhibited to his friends a pair of native shoes fancifully gilded. Another, with more foresight, brought home five hundred pairs, ungilded, and offered them for sale. They were thick, clumsily shaped, and heavy, but they sold. There was a demand for more. In a few years half a million pairs were being imported annually. New England manufacturers bid against one another along the wharves for the gum which had been used as ballast and began to make rubber shoes.

European vessels had also carried rubber home;

and experiments were being made with it in France and Britain. A Frenchman manufactured suspenders by cutting a native bottle into fine threads and running them through a narrow cloth web. And Macintosh, a chemist of Glasgow, inserted rubber treated with naphtha between thin pieces of cloth and evolved the garment that still bears his name.

At first the new business in rubber yielded profits. The cost of the raw material was infinitesimal; and there was a demand for the finished articles. In Roxbury, Massachusetts, a firm manufacturing patent leather treated raw rubber with turpentine and lampblack and spread it on cloth, in an effort to produce a waterproof leather. The process appeared to be a complete success, and a large capital was employed to make handsome shoes and clothing out of the new product and in opening shops in the large cities for their sale. Merchants throughout the country placed orders for these goods, which, as it happened, were made and shipped in winter.

But, when summer came, the huge profits of the manufacturers literally melted away, for the beautiful garments decomposed in the heat; and loads of them, melting and running together, were being returned to the factory. And they filled Roxbury

with such noisome odors that they had to be taken out at dead of night and buried deep in the earth.

And not only did these rubber garments melt in the heat. It presently transpired that severe frost stiffened them to the rigidity of granite. Daniel Webster had had some experience in this matter himself. "A friend in New York," he said, "sent me a very fine cloak of India Rubber, and a hat of the same material. I did not succeed very well with them. I took the cloak one day and set it out in the cold. It stood very well by itself. I surmounted it with the hat, and many persons passing by supposed they saw, standing by the porch, the Farmer of Marshfield."

It was in the year 1834, shortly after the Roxbury manufacturers had come to realize that their process was worthless and that their great fortune was only a mirage, and just before these facts became generally known, that Charles Goodyear made his entrance on the scene. He appeared first as a customer in the company's store in New York and bought a rubber life-preserver. When he returned some weeks later with a plan for improving the tube, the manager confided to him the sad tragedy of rubber, pointing out that no improvement in the manufactured articles would meet the

difficulty, but that fame and fortune awaited the inventor of a process that would keep rubber dry and firm and flexible in all weathers.

Goodyear felt that he had a call from God. "He who directs the operations of the mind," he wrote at a later date, "can turn it to the development of the properties of Nature in his own way, and at the time when they are specially needed. The creature imagines he is executing some plan of his own, while he is simply an instrument in the hands of his Maker for executing the divine purposes of beneficence to the race." It was in the spirit of a crusader, consecrated to a particular service, that this man took up the problem of rubber. The words quoted are a fitting preface for the story of the years that followed, which is a tale of endurance and persistent activity under sufferings and disappointments such as are scarcely paralleled even in the pages of invention, darkened as they often are by poverty and defeat.

Charles Goodyear was born at New Haven, December 29, 1800, the son of Amasa Goodyear and descendant of Stephen Goodyear who was associated with Theophilus Eaton, the first governor of the Puritan colony of New Haven. It was natural that Charles should turn his mind to

invention, as he did even when a boy; for his father, a pioneer in the manufacture of American hardware, was the inventor of a steel hayfork which replaced the heavy iron fork of prior days and lightened and expedited the labor of the fields. When Charles was seven his father moved to Naugatuck and manufactured the first pearl buttons made in America; during the War of 1812 the Goodyear factory supplied metal buttons to the Government. Charles, a studious, serious boy, was the close companion of his father. His deeply religious nature manifested itself early, and he joined the Congregational Church when he was sixteen. It was at first his intention to enter the ministry, which seemed to him to offer the most useful career of service, but, changing his mind, he went to Philadelphia to learn the hardware business and on coming of age was admitted to partnership in a firm established there by his father. The firm prospered for a time, but an injudicious extension of credit led to its suspension. So it happened that Goodyear in 1834, when he became interested in rubber, was an insolvent debtor, liable, under the laws of the time, to imprisonment. Soon afterward, indeed, he was lodged in the Debtor's Prison in Philadelphia.

It would seem an inauspicious hour to begin a search which might lead him on in poverty for years and end nowhere. But, having seen the need for perfect rubber, the thought had come to him, with the force of a religious conviction, that "an object so desirable and so important, and so necessary to man's comfort, as the making of gum-elastic available to his use, was most certainly placed within his reach." Thereafter he never doubted that God had called him to this task and that his efforts would be crowned with success. Concerning his prison experiences, of which the first was not to be the last, he says that "notwithstanding the mortification attending such a trial," if the prisoner has a real aim "for which to live and hope over he may add firmness to hope, and derive lasting advantage by having proved to himself that, with a clear conscience and a high purpose, a man may be as happy within prison walls as in any other (even the most fortunate) circumstances in life." With this spirit he met every reverse throughout the ten hard years that followed.

Luckily, as he says, his first experiments required no expensive equipment. Fingers were the best tools for working the gum. The prison officials allowed him a bench and a marble slab, a friend

procured him a few dollars' worth of gum, which sold then at five cents a pound, and his wife contributed her rolling pin. That was the beginning.

For a time he believed that, by mixing the raw gum with magnesia and boiling it in lime, he had overcome the stickiness which was the inherent difficulty. He made some sheets of white rubber which were exhibited, and also some articles for sale. His hopes were dashed when he found that weak acid, such as apple juice or vinegar, destroyed his new product. Then in 1836 he found that the application of aqua fortis, or nitric acid, produced a "curing" effect on the rubber and thought that he had discovered the secret. Finding a partner with capital, he leased an abandoned rubber factory on Staten Island. But his partner's fortune was swept away in the panic of 1837, leaving Good-year again an insolvent debtor. Later he found another partner and went to manufacturing in the deserted plant at Roxbury, with an order from the Government for a large number of mail bags. This order was given wide publicity and it aroused the interest of manufacturers throughout the country. But by the time the goods were ready for delivery the first bags made had rotted from their handles. Only the surface of the rubber had been "cured."

This failure was the last straw, as far as Goodyear's friends were concerned. Only his patient and devoted wife stood by him; she had labored, known want, seen her children go hungry to school, but she seems never to have reproached her husband nor to have doubted his ultimate success. The gentleness and tenderness of his deportment in the home made his family cling to him with deep affection and bear willingly any sacrifice for his sake; though his successive failures generally meant a return of the inventor to the debtor's prison and the casting of his family upon charity.

The nitric acid process had not solved the problem but it had been a real step forward. It was in the year 1839, by an accident, that he discovered the true process of vulcanization which cured not the surface alone but the whole mass. He was trying to harden the gum by boiling it with sulphur on his wife's cookstove when he let fall a lump of it on the red hot iron top. It vulcanized instantly. This was an accident which only Goodyear could have interpreted. And it was the last. The strange substance from the jungles of the tropics had been mastered. It remained, however, to perfect the process, to ascertain the accurate formula and the exact degree of heat.

The Goodyears were so poor during these years that they received at any time a barrel of flour from a neighbor thankfully. There is a tradition that on one occasion, when Goodyear desired to cross between Staten Island and New York, he had to give his umbrella to the ferry master as security for his fare, and that the name of the ferry master was Cornelius Vanderbilt, "a man who made much money because he took few chances." The incident may easily have occurred, though the ferry master could hardly have been Vanderbilt himself, unless it had been at an earlier date. Another tradition says that one of Goodyear's neighbors described him to an inquisitive stranger thus: "You will know him when you see him; he has on an India rubber cap, stock, coat, vest, and shoes, and an India rubber purse *without a cent in it!*"

Goodyear's trials were only beginning. He had the secret at last, but nobody would believe him. He had worn out even the most sanguine of his friends. "That such indifference to this discovery, and many incidents attending it, could have existed in an intelligent and benevolent community," wrote Goodyear later, "can only be accounted for by existing circumstances in that community. The great losses that had been sustained in the

manufacture of gum-elastic: the length of time the inventor had spent in what appeared to them to be entirely fruitless efforts to accomplish anything with it; added to his recent misfortunes and disappointments, all conspired, with his utter destitution, to produce a state of things as unfavorable to the promulgation of the discovery as can well be imagined. He, however, felt in duty bound to beg in earnest, if need be, sooner than that the discovery should be lost to the world and to himself.

. . . How he subsisted at this period charity alone can tell, for it is as well to call things by their right names; and it is little else than charity when the lender looks upon what he parts with as a gift. The pawning or selling some relic of better days or some article of necessity was a frequent expedient. His library had long since disappeared, but shortly after the discovery of this process, he collected and sold at auction the schoolbooks of his children, which brought him the trifling sum of five dollars; small as the amount was, it enabled him to proceed. At this step he did not hesitate. The occasion, and the certainty of success, warranted the measure which, in other circumstances, would have been sacrilege."

His itinerary during those years is eloquent.

Wherever there was a man, who had either a grain of faith in rubber or a little charity for a frail and penniless monomaniac, thither Goodyear made his way. The goal might be an attic room or shed to live in rent free, or a few dollars for a barrel of flour for the family and a barrel of rubber for himself, or permission to use a factory's ovens after hours and to hang his rubber over the steam valves while work went on. From Woburn in 1839, the year of his great discovery, he went to Lynn, from Lynn back to the deserted factory at Roxbury. Again to Woburn, to Boston, to Northampton, to Springfield, to Naugatuck; in five years as many removes. When he lacked boat or railway fare, and he generally did, he walked through winds and rains and drifting snow, begging shelter at some cottage or farm where a window lamp gleamed kindly.

Goodyear took out his patent in 1844. The process he invented has been changed little, if at all, from that day to this. He also invented the perfect India rubber cloth by mixing fiber with the gum — a discovery he considered rightly as secondary in importance only to vulcanization. When he died in 1860 he had taken out sixty patents on rubber manufactures. He had seen his invention applied to several hundred uses, giving employment to

sixty thousand persons, producing annually eight million dollars' worth of merchandise—numbers which would form but a fraction of the rubber statistics of today.

Everybody, the whole civilized world round, uses rubber in one form or another. And rubber makes a belt around the world in its natural as well as in its manufactured form. The rubber-bearing zone winds north and south of the equator through both hemispheres. In South America rubber is the latex of certain trees, in Africa of trees and vines. The best "wild" rubber still comes from Pará in Brazil. It is gathered and prepared for shipment there today by the same methods the natives used four hundred years ago. The natives in their canoes follow the watercourses into the jungles. They cut V-shaped or spiral incisions in the trunks of the trees that grow sheer to sixty feet before spreading their shade. At the base of the incisions they affix small clay cups, like swallows' nests. Over the route they return later with large gourds in which they collect the fluid from the clay cups. The filled gourds they carry to their village of grass huts and there they build their smoky fires of oily palm nuts. Dipping paddles into the fluid gum they turn and harden it, a coating at a time, in the

smoke. The rubber "biscuit" is cut from the paddle with a wet knife when the desired thickness has been attained.

Goodyear lived for sixteen years after his discovery of the vulcanization process. During the last six he was unable to walk without crutches. He was indifferent to money. To make his discoveries of still greater service to mankind was his whole aim. It was others who made fortunes out of his inventions. Goodyear died a poor man.

In his book, a copy of which was printed on gum-elastic sheets and bound in hard rubber carved, he summed up his philosophy in this statement: "The writer is not disposed to repine and say that he has planted and others have gathered the fruits. The advantages of a career in life should not be estimated exclusively by the standard of dollars and cents, as it is too often done. Man has just cause for regret when he sows and no one reaps."

CHAPTER VIII

PIONEERS OF THE MACHINE SHOP

THERE is a tinge of melancholy about the life of such a pioneer as Oliver Evans, that early American mechanic of great genius, whose story is briefly outlined in a preceding chapter. Here was a man of imagination and sensibility, as well as practical power; conferring great benefits on his countrymen, yet in chronic poverty; derided by his neighbors, robbed by his beneficiaries; his property, the fruit of his brain and toil, in the end malevolently destroyed. The lot of the man who sees far ahead of his time, and endeavors to lead his fellows in ways for which they are not prepared, has always been hard.

John Stevens, too, as we have seen, met defeat when he tried to thrust a steam railroad on a country that was not yet ready for it. His mechanical conceptions were not marked by genius equal to that of Evans, but they were still too far advanced

to be popular. The career of Stevens, however, presents a remarkable contrast to that of Evans in other respects. Evans was born poor (in Delaware, 1755) and remained poor all his life. Stevens was born rich (in New York City, 1749) and remained rich all his life. Of the family of Evans nothing is known either before or after him. Stevens, on the contrary, belonged to one of the best known and most powerful families in America. His grandfather, John Stevens I, came from England in 1699 and made himself a lawyer and a great landowner. His father, John Stevens II, was a member from New Jersey of the Continental Congress and presided at the New Jersey Convention which ratified the Constitution.

John Stevens III was graduated at King's College (Columbia) in 1768. He held public offices during the Revolution. To him, perhaps more than to any other man, is due the Patent Act of 1790, for the protection of American inventors, for that law was the result of a petition which he made to Congress and which, being referred to a committee, was favorably reported. Thus we may regard John Stevens as the father of the American patent law.

John Stevens owned the old Dutch farm on the

Hudson on which the city of Hoboken now stands. The place had been in possession of the Bayard family, but William Bayard, who lived there at the time of the Revolution, was a Loyalist, and his house on Castle Point was burned down and his estate confiscated. After the Revolution Stevens acquired the property. He laid it out as a town in 1804, made it his summer residence, and established there the machine shops in which he and his sons carried on their mechanical experiments.

These shops were easily the largest and best-equipped in the Union when in 1838 John Stevens died at the age of ninety. The four brothers, John Cox, Robert Livingston, James Alexander, and Edwin Augustus, worked harmoniously together. "No one ever heard of any quarrel or dissension in the Stevens family. They were workmen themselves, and they were superior to their subordinates because they were better engineers and better men of business than any other folk who up to that time had undertaken the business of transportation in the United States."¹

The youngest of these brothers, Edwin Augustus Stevens, dying in 1868, left a large part of his

¹ Abram S. Hewitt. Quoted in Iles, *Leading American Inventors*, p. 37.

fortune to found the Stevens Institute of Technology, afterwards erected at Hoboken not far from the old family homestead on Castle Point. The mechanical star of the family, however, was the second brother, Robert Livingston Stevens, whose many inventions made for the great improvement of transportation both by land and water. For a quarter of a century, from 1815 to 1840, he was the foremost builder of steamboats in America, and under his hand the steamboat increased amazingly in speed and efficiency. He made great contributions to the railway. The first locomotives ran upon wooden stringers plated with strap iron. A loose end — “a snakehead” it was called — sometimes curled up and pierced through the floor of a car, causing a wreck. The solid metal T-rail, now in universal use, was designed by Stevens and was first used on the Camden and Amboy Railroad, of which he was president and his brother Edwin treasurer and manager. The swivel truck and the cow-catcher, the modern method of attaching rails to ties, the vestibule car, and many improvements in the locomotive were also first introduced on the Stevens road.

The Stevens brothers exerted their influence also on naval construction. A double invention of

Robert and Edwin, the forced draft, to augment steam power and save coal, and the air-tight fire-room, which they applied to their own vessels, was afterwards adopted by all navies. Robert designed and projected an ironclad battleship, the first one in the world. This vessel, called the Stevens Battery, was begun by authority of the Government in 1842; but, owing to changes in the design and inadequate appropriations by Congress, it was never launched. It lay for many years in the basin at Hoboken an unfinished hulk. Robert died in 1856. On the outbreak of the Civil War, Edwin tried to revive the interest of the Government, but by that time the design of the Stevens Battery was obsolete, and Edwin Stevens was an old man. So the honors for the construction of the first ironclad man-of-war to fight and win a battle went to John Ericsson, that other great inventor, who built the famous *Monitor* for the Union Government.

Carlyle's oft-quoted term, "Captains of Industry," may fittingly be applied to the Stevens family. Strong, masterful, and farseeing, they used ideas, their own and those of others, in a large way, and were able to succeed where more timorous inventors failed. Without the stimulus of poverty they achieved success, making in their shops

that combination of men and material which not only added to their own fortunes but also served the world.

We left Eli Whitney defeated in his efforts to divert to himself some adequate share of the untold riches arising from his great invention of the cotton gin. Whitney, however, had other sources of profit in his own character and mechanical ability. As early as 1798 he had turned his talents to the manufacture of firearms. He had established his shops at Whitneyville, near New Haven; and it was there that he worked out another achievement quite as important economically as the cotton gin, even though the immediate consequences were less spectacular: namely, the principle of standardization or interchangeability in manufacture.

This principle is the very foundation today of all American large-scale production. The manufacturer produces separately thousands of copies of every part of a complicated machine, confident that an equal number of the complete machine will be assembled and set in motion. The owner of a motor car, a reaper, a tractor, or a sewing machine, orders, perhaps by telegraph or telephone, a broken or lost part, taking it for granted that the new part

can be fitted easily and precisely into the place of the old.

Though it is probable that this idea of standardization, or interchangeability, originated independently in Whitney's mind, and though it is certain that he and one of his neighbors, who will be mentioned presently, were the first manufacturers in the world to carry it out successfully in practice, yet it must be noted that the idea was not entirely new. We are told that the system was already in operation in England in the manufacture of ship's blocks. From no less an authority than Thomas Jefferson we learn that a French mechanic had previously conceived the same idea.¹ But, as no general result whatever came from the idea in either France or England, the honors go to Whitney and North, since they carried it to such complete success that it spread to other branches of manufacturing. And in the face of opposition. When Whitney wrote that his leading object was "to substitute correct and effective operations of machinery for that skill of the artist which is acquired only by long practice and experience," in order to make the same parts of different guns "as

¹ See the letter from Jefferson to John Jay, of April 30, 1785, cited in Roe, *English and American Tool Builders*, p. 129.

much like each other as the successive impressions of a copper-plate engraving," he was laughed to scorn by the ordnance officers of France and England. "Even the Washington officials," says Roe, "were sceptical and became uneasy at advancing so much money without a single gun having been completed, and Whitney went to Washington, taking with him ten pieces of each part of a musket. He exhibited these to the Secretary of War and the army officers interested, as a succession of piles of different parts. Selecting indiscriminately from each of the piles, he put together ten muskets, an achievement which was looked on with amazement."¹

While Whitney worked out his plans at Whitneyville, Simeon North, another Connecticut mechanic and a gunmaker by trade, adopted the same system. North's first shop was at Berlin. He afterwards moved to Middletown. Like Whitney, he used methods far in advance of the time. Both Whitney and North helped to establish the United States Arsenal at Springfield, Massachusetts, and at Harper's Ferry, Virginia, in which their methods were adopted. Both the Whitney and North plants survived their founders. Just before the

¹ Roe, *English and American Tool Builders*, p. 133.

Mexican War the Whitney plant began to use steel for gun barrels, and Jefferson Davis, Colonel of the Mississippi Rifles, declared that the new guns were "the best rifles which had ever been issued to any regiment in the world." Later, when Davis became Secretary of War, he issued to the regular army the same weapon.

The perfection of Whitney's tools and machines made it possible to employ workmen of little skill or experience. "Indeed so easy did Mr. Whitney find it to instruct new and inexperienced workmen, that he uniformly preferred to do so, rather than to combat the prejudices of those who had learned the business under a different system."¹ This reliance upon the machine for precision and speed has been a distinguishing mark of American manufacture. A man or a woman of little actual mechanical skill may make an excellent machine tender, learning to perform a few simple motions with great rapidity.

Whitney married in 1817 Miss Henrietta Edwards, daughter of Judge Pierpont Edwards, of New Haven, and granddaughter of Jonathan Edwards. His business prospered, and his high character, agreeable manners, and sound judgment won

¹ Denison Olmstead, *Memoir*, cited by Roe, p. 159.

for him the highest regard of all who knew him; and he had a wide circle of friends. It is said that he was on intimate terms with every President of the United States from George Washington to John Quincy Adams. But his health had been impaired by hardships endured in the South, in the long struggle over the cotton gin, and he died in 1825, at the age of fifty-nine. The business which he founded remained in his family for ninety years. It was carried on after his death by two of his nephews and then by his son, until 1888, when it was sold to the Winchester Repeating Arms Company of New Haven.

Here then, in these early New England gunshops, was born the American system of interchangeable manufacture. Its growth depended upon the machine tool, that is, the machine for making machines. Machine tools, of course, did not originate in America. English mechanics were making machines for cutting metal at least a generation before Whitney. One of the earliest of these English pioneers was John Wilkinson, inventor and maker of the boring machine which enabled Boulton and Watt in 1776 to bring their steam engine to the point of practicability. Without this machine Watt found it impossible to bore his

cylinders with the necessary degree of accuracy.¹ From this one fact, that the success of the steam engine depended upon the invention of a new tool, we may judge of what a great part the inventors of machine tools, of whom thousands are unnamed and unknown, have played in the industrial world.

So it was in the shops of the New England gun-makers that machine tools were first made of such variety and adaptability that they could be applied generally to other branches of manufacturing; and so it was that the system of interchangeable manufacture arose as a distinctively American development. We have already seen how England's policy of keeping at home the secrets of her machinery led to the independent development of the spindles and looms of New England. The same policy affected the tool industry in America in the same way and bred in the new country a race of original and resourceful mechanics.

One of these pioneers was Thomas Blanchard, born in 1788 on a farm in Worcester County, Massachusetts, the home also of Eli Whitney and Elias Howe. Tom began his mechanical career at the age of thirteen by inventing a device to pare apples. At the age of eighteen he went to work in

¹ Roe, *English and American Tool Builders*, p. 1 *et seq.*

his brother's shop, where tacks were made by hand, and one day took to his brother a mechanical device for counting the tacks to go into a single packet. The invention was adopted and was found to save the labor of one workman. Tom's next achievement was a machine to make tacks, on which he spent six years and the rights of which he sold for five thousand dollars. It was worth far more, for it revolutionized the tack industry, but such a sum was to young Blanchard a great fortune.

The tack-making machine gave Blanchard a reputation, and he was presently sought out by a gun manufacturer, to see whether he could improve the lathe for turning the barrels of the guns. Blanchard could; and did. His next problem was to invent a lathe for turning the irregular wooden stocks. Here he also succeeded and produced a lathe that would copy precisely and rapidly any pattern. It is from this invention that the name of Blanchard is best known. The original machine is preserved in the United States Armory at Springfield, to which Blanchard was attached for many years, and where scores of the descendants of his copying lathe may be seen in action today.

Turning gunstocks was, of course, only one of the many uses of Blanchard's copying lathe. Its chief

use, in fact, was in the production of wooden lasts for the shoemakers of New England, but it was applied to many branches of wood manufacture, and later on the same principle was applied to the shaping of metal.

Blanchard was a man of many ideas. He built a steam vehicle for ordinary roads and was an early advocate of railroads; he built steamboats to ply upon the Connecticut and incidentally produced in connection with these his most profitable invention, a machine to bend ship's timbers without splintering them. The later years of his life were spent in Boston, and he often served as a patent expert in the courts, where his wide knowledge, hard common sense, incisive speech, and homely wit made him a welcome witness.

We now glance at another New England inventor, Samuel Colt, the man who carried Whitney's conceptions to transcendent heights, the most dashing and adventurous of all the pioneers of the machine shop in America. If "the American frontier was Elizabethan in quality," there was surely a touch of the Elizabethan spirit on the man whose invention so greatly affected the character of that frontier. Samuel Colt was born at Hartford in 1814 and died there in 1862 at the age of forty-eight,

leaving behind him a famous name and a colossal industry of his own creation. His father was a small manufacturer of silk and woolens at Hartford, and the boy entered the factory at a very early age. At school in Amherst a little later, he fell under the displeasure of his teachers. At thirteen he took to sea, as a boy before the mast, on the East India voyage to Calcutta. It was on this voyage that he conceived the idea of the revolver and whittled out a wooden model. On his return he went into his father's works and gained a superficial knowledge of chemistry from the manager of the bleaching and dyeing department. Then he took to the road for three years and traveled from Quebec to New Orleans lecturing on chemistry under the name of "Dr. Coult." The main feature of his lecture was the administration of nitrous oxide gas to volunteers from the audience, whose antics and the amusing showman's patter made the entertainment very popular.

Colt's ambition, however, soared beyond the occupation of itinerant showman, and he never forgot his revolver. As soon as he had money enough, he made models of the new arm and took out his patents; and, having enlisted the interest of capital, he set up the Patent Arms Company at Paterson,

New Jersey, to manufacture the revolver. He did not succeed in having the revolver adopted by the Government, for the army officers for a long time objected to the percussion cap (an invention, by the way, then some twenty years old, which was just coming into use and without which Colt's revolver would not have been practicable) and thought that the new weapon might fail in an emergency. Colt found a market in Texas and among the frontiersmen who were fighting the Seminole War in Florida, but the sales were insufficient, and in 1842 the company was obliged to confess insolvency and close down the plant. Colt bought from the company the patent of the revolver, which was supposed to be worthless.

Nothing more happened until after the outbreak of the Mexican War in 1846. Then came a loud call from General Zachary Taylor for a supply of Colt's revolvers. Colt had none. He had sold the last one to a Texas ranger. He had not even a model. Yet he took an order from the Government for a thousand and proceeded to construct a model. For the manufacture of the revolvers he arranged with the Whitney plant at Whitneyville. There he saw and scrutinized every detail of the factory system that Eli Whitney had established

forty years earlier. He resolved to have a plant of his own on the same system and one that would far surpass Whitney's. Next year (1848) he rented premises in Hartford. His business prospered and increased. At last the Government demanded his revolvers. Within five years he had procured a site of two hundred and fifty acres fronting the Connecticut River at Hartford, and had there begun the erection of the greatest arms factory in the world.

Colt was a captain of captains. The ablest mechanic and industrial organizer in New England at that time was Elisha K. Root. Colt went after him, outbidding every other bidder for his services, and brought him to Hartford to supervise the erection of the new factory and set up its machinery. Root was a great superintendent, and the phenomenal success of the Colt factory was due in a marked degree to him. He became president of the company after Colt's death in 1862, and under him were trained a large number of mechanics and inventors of new machine tools, who afterwards became celebrated leaders and officers in the industrial armies of the country.

The spectacular rise of the Colt factory at Hartford drew the attention of the British Government,

and in 1854 Colt was invited to appear in London before a Parliamentary Committee on Small Arms. He lectured the members of the committee as if they had been school boys, telling them that the regular British gun was so bad that he would be ashamed to have it come from his shop. Speaking of a plant which he had opened in London the year before he criticized the supposedly skilled British mechanic, saying: "I began here by employing the highest-priced men that I could find to do difficult things, but I had to remove the whole of these high-priced men. Then I tried the cheapest I could find, and the more ignorant a man was, the more brains he had for my purpose; and the result was this: I had men now in my employ that I started with at two shillings a day, and in one short year I can not spare them at eight shillings a day." ¹ Colt's audacity, however, did not offend the members of the committee and they decided to visit his American factory at Hartford. They did; and were so impressed that the British Government purchased in America a full set of machines for the manufacture of arms in the Royal Small Arms factory at Enfield, England, and took across the sea American workmen and foremen to set up and run these

¹ Henry Barnard, *Armsmear*, p. 371.

machines. A demand sprang up in Europe for Blanchard copying lathes and a hundred other American tools, and from this time on the manufacture of tools and appliances for other manufacturers, both at home and abroad, became an increasingly important industry of New England.

The system which the gunmakers worked out and developed to meet their own requirements was capable of indefinite expansion. It was easily adapted to other kinds of manufacture. So it was that as new inventions came in the manufacturers of these found many of the needed tools ready for them, and any special modifications could be quickly made. A manufacturer of machine tools will produce on demand a device to perform any operation, however difficult or intricate. Some of the machines are so versatile that specially designed sets of cutting edges will adapt them to almost any work.

Standardization, due to the machine tool, is one of the chief glories of American manufacturing. Accurate watches and clocks, bicycles and motor cars, innumerable devices to save labor in the home, the office, the shop, or on the farm, are within the reach of all, because the machine tool, tended by labor comparatively unskilled, does the greater

part of the work of production. In the crisis of the World War, American manufacturers, turning from the arts of peace, promptly adapted their plants to the manufacture of the most complicated engines of destruction, which were produced in Europe only by skilled machinists of the highest class.

CHAPTER IX

THE FATHERS OF ELECTRICITY

IT may startle some reader to be told that the foundations of modern electrical science were definitely established in the Elizabethan Age. The England of Elizabeth, of Shakespeare, of Drake and the sea-dogs, is seldom thought of as the cradle of the science of electricity. Nevertheless, it was; just as surely as it was the birthplace of the Shakespearian drama, of the Authorized Version of the Bible, or of that maritime adventure and colonial enterprise which finally grew and blossomed into the United States of America.

The accredited father of the science of electricity and magnetism is William Gilbert, who was a physician and man of learning at the court of Elizabeth. Prior to him, all that was known of these phenomena was what the ancients knew, that the lodestone possessed magnetic properties and that amber and jet, when rubbed, would attract bits of

paper or other substances of small specific gravity. Gilbert's great treatise *On the Magnet*, printed in Latin in 1600, containing the fruits of his researches and experiments for many years, indeed provided the basis for a new science.

On foundations well and truly laid by Gilbert several Europeans, like Otto von Guericke of Germany, Du Fay of France, and Stephen Gray of England, worked before Benjamin Franklin and added to the structure of electrical knowledge. The Leyden jar, in which the mysterious force could be stored, was invented in Holland in 1745 and in Germany almost simultaneously.

Franklin's important discoveries are outlined in the first chapter of this book. He found out, as we have seen, that electricity and lightning are one and the same, and in the lightning rod he made the first practical application of electricity. Afterwards Cavendish of England, Coulomb of France, Galvani of Italy, all brought new bricks to the pile. Following them came a group of master builders, among whom may be mentioned: Volta of Italy, Oersted of Denmark, Ampère of France, Ohm of Germany, Faraday of England, and Joseph Henry of America.

Among these men, who were, it should be noted,

theoretical investigators, rather than practical inventors like Morse, or Bell, or Edison, the American Joseph Henry ranks high. Henry was born at Albany in 1799 and was educated at the Albany Academy. Intending to practice medicine, he studied the natural sciences. He was poor and earned his daily bread by private tutoring. He was an industrious and brilliant student and soon gave evidence of being endowed with a powerful mind. He was appointed in 1824 an assistant engineer for the survey of a route for a State road, three hundred miles long, between the Hudson River and Lake Erie. The experience he gained in this work changed the course of his career; he decided to follow civil and mechanical engineering instead of medicine. Then in 1826 he became teacher of mathematics and natural philosophy in the Albany Academy.

It was in the Albany Academy that he began that wide series of experiments and investigations which touched so many phases of the great problem of electricity. His first discovery was that a magnet could be immensely strengthened by winding it with insulated wire. He was the first to employ insulated wire wound as on a spool and was able finally to make a magnet which would lift

thirty-five hundred pounds. He first showed the difference between "quantity" magnets composed of short lengths of wire connected in parallel, excited by a few large cells, and "intensity" magnets wound with a single long wire and excited by a battery composed of cells in series. This was an original discovery, greatly increasing both the immediate usefulness of the magnet and its possibilities for future experiments.

The learned men of Europe, Faraday, Sturgeon, and the rest, were quick to recognize the value of the discoveries of the young Albany schoolmaster. Sturgeon magnanimously said: "Professor Henry has been enabled to produce a magnetic force which totally eclipses every other in the whole annals of magnetism; and no parallel is to be found since the miraculous suspension of the celebrated Oriental imposter in his iron coffin."¹

Henry also discovered the phenomena of self induction and mutual induction. A current sent through a wire in the second story of the building induced currents through a similar wire in the cellar two floors below. In this discovery Henry anticipated Faraday though his results as to mutual induction were not published until he had heard

¹ *Philosophical Magazine*, vol. XI, p. 199 (March, 1832).

rumors of Faraday's discovery, which he thought to be something different.

The attempt to send signals by electricity had been made many times before Henry became interested in the problem. On the invention of Sturgeon's magnet there had been hopes in England of a successful solution, but in the experiments that followed the current became so weak after a few hundred feet that the idea was pronounced impracticable. Henry strung a mile of fine wire in the Academy, placed an "intensity" battery at one end, and made the armature strike a bell at the other. Thus he discovered the essential principle of the electric telegraph. This discovery was made in 1831, the year before the idea of a working electric telegraph flashed on the mind of Morse. There was no occasion for the controversy which took place later as to who invented the telegraph. That was Morse's achievement, but the discovery of the great fact, which startled Morse into activity, was Henry's achievement. In Henry's own words: "This was the first discovery of the fact that a galvanic current could be transmitted to a great distance with so little a diminution of force as to produce mechanical effects, and of the means by which the transmission could be accomplished. I saw

that the electric telegraph was now practicable." He says further, however: "I had not in mind any particular form of telegraph, but referred only to the general fact that it was now demonstrated that a galvanic current could be transmitted to great distances, with sufficient power to produce mechanical effects adequate to the desired object."¹

Henry next turned to the possibility of a magnetic engine for the production of power and succeeded in making a reciprocating-bar motor, on which he installed the first automatic pole changer, or commutator, ever used with an electric battery. He did not succeed in producing direct rotary motion. His bar oscillated like the walking beam of a steamboat.

Henry was appointed in 1832 Professor of Natural Philosophy in the College of New Jersey, better known today as Princeton University. There he repeated his old experiments on a larger scale, confirmed Steinheil's experiment of using the earth as return conductor, showed how a feeble current would be strengthened, and how a small magnet could be used as a circuit maker and breaker. Here were the principles of the telegraph relay and the dynamo.

¹Deposition of Joseph Henry, September 7, 1849, printed in Morse, *The Electro-Magnetic Telegraph*, p. 91.

Why, then, if the work of Henry was so important, is his name almost forgotten, except by men of science, and not given to any one of the practical applications of electricity? The answer is plain. Henry was an investigator, not an inventor. He states his position very clearly: "I never myself attempted to reduce the principles to practice, or to apply any of my discoveries to processes in the arts. My whole attention exclusive of my duties to the College, was devoted to original scientific investigations, and I left to others what I considered in a scientific view of subordinate importance — the application of my discoveries to useful purposes in the arts. Besides this I partook of the feeling common to men of science, which disinclines them to secure to themselves the advantages of their discoveries by a patent."

Then, too, his talents were soon turned to a wider field. The bequest of James Smithson, that far-sighted Englishman, who left his fortune to the United States to found "the Smithsonian Institution, for the increase and diffusion of knowledge among men," was responsible for the diffusion of Henry's activities. The Smithsonian Institution was founded at Washington in 1846, and Henry was fittingly chosen its Secretary, that is, its chief

executive officer. And from that time until his death in 1878, over thirty years, he devoted himself to science in general.

He studied terrestrial magnetism and building materials. He reduced meteorology to a science, collecting reports by telegraph, made the first weather map, and issued forecasts of the weather based upon definite knowledge rather than upon signs. He became a member of the Lighthouse Board in 1852 and was the head after 1871. The excellence of marine illuminants and fog signals to-day is largely due to his efforts. Though he was later drawn into a controversy with Morse over the credit for the invention of the telegraph, he used his influence to procure the renewal of Morse's patent. He listened with attention to Alexander Graham Bell, who had the idea that electric wires might be made to carry the human voice, and encouraged him to proceed with his experiments. "He said," Bell writes, "that he thought it was the germ of a great invention and advised me to work at it without publishing. I said that I recognized the fact that there were mechanical difficulties in the way that rendered the plan impracticable at the present time. I added that I felt that I had not the electrical knowledge necessary to overcome the

difficulties. His laconic answer was, 'GET IT!' I cannot tell you how much these two words have encouraged me."

Henry had blazed the way for others to work out the principles of the electric motor, and a few experimenters attempted to follow his lead. Thomas Davenport, a blacksmith of Brandon, Vermont, built an electric car in 1835, which he was able to drive on the road, and so made himself the pioneer of the automobile in America. Twelve years later Moses G. Farmer exhibited at various places in New England an electric-driven locomotive, and in 1851 Charles Grafton Page drove an electric car, on the tracks of the Baltimore and Ohio Railroad, from Washington to Bladensburg, at the rate of nineteen miles an hour. But the cost of batteries was too great and the use of the electric motor in transportation not yet practicable.

The great principle of the dynamo, or electric generator, was discovered by Faraday and Henry but the process of its development into an agency of practical power consumed many years; and without the dynamo for the generation of power the electric motor had to stand still and there could be no practicable application of electricity to transportation, or manufacturing, or lighting. So it was

that, except for the telegraph, whose story is told in another chapter, there was little more American achievement in electricity until after the Civil War.

The arc light as a practical illuminating device came in 1878. It was introduced by Charles F. Brush, a young Ohio engineer and graduate of the University of Michigan. Others before him had attacked the problem of electric lighting, but lack of suitable carbons stood in the way of their success. Brush overcame the chief difficulties and made several lamps to burn in series from one dynamo. The first Brush lights used for street illumination were erected in Cleveland, Ohio, and soon the use of arc lights became general. Other inventors improved the apparatus, but still there were drawbacks. For outdoor lighting and for large halls they served the purpose, but they could not be used in small rooms. Besides, they were in series, that is, the current passed through every lamp in turn, and an accident to one threw the whole series out of action. The whole problem of indoor lighting was to be solved by one of America's most famous inventors.

The antecedents of Thomas Alva Edison in America may be traced back to the time when Franklin was beginning his career as a printer in

Philadelphia. The first American Edisons appear to have come from Holland about 1730 and settled on the Passaic River in New Jersey. Edison's grandfather, John Edison, was a Loyalist in the Revolution who found refuge in Nova Scotia and subsequently moved to Upper Canada. His son, Samuel Edison, thought he saw a moral in the old man's exile. His father had taken the King's side and had lost his home; Samuel would make no such error. So, when the Canadian Rebellion of 1837 broke out, Samuel Edison, aged thirty-three, arrayed himself on the side of the insurgents. This time, however, the insurgents lost, and Samuel was obliged to flee to the United States, just as his father had fled to Canada. He finally settled at Milan, Ohio, and there, in 1847, in a little brick house, which is still standing, Thomas Alva Edison was born.

When the boy was seven the family moved to Port Huron, Michigan. The fact that he attended school only three months and soon became self-supporting was not due to poverty. His mother, an educated woman of Scotch extraction, taught him at home after the schoolmaster reported that he was "addled." His desire for money to spend on chemicals for a laboratory which he had fitted

up in the cellar led to his first venture in business. "By a great amount of persistence," he says, "I got permission to go on the local train as newsboy. The local train from Port Huron to Detroit, a distance of sixty-three miles, left at 7 A.M. and arrived again at 9.30 P.M. After being on the train for several months I started two stores in Port Huron — one for periodicals, and the other for vegetables, butter, and berries in the season. They were attended by two boys who shared in the profits." Moreover, young Edison bought produce from the farmers' wives along the line which he sold at a profit. He had several newsboys working for him on other trains; he spent hours in the Public Library in Detroit; he fitted up a laboratory in an unused compartment of one of the coaches, and then bought a small printing press which he installed in the car and began to issue a newspaper which he printed on the train. All before he was fifteen years old.

But one day Edison's career as a traveling newsboy came to a sudden end. He was at work in his moving laboratory when a lurch of the train jarred a stick of burning phosphorus to the floor and set the car on fire. The irate conductor ejected him at the next station, giving him a violent box on the

ear, which permanently injured his hearing, and dumped his chemicals and printing apparatus on the platform.

Having lost his position, young Edison soon began to dabble in telegraphy, in which he had already become interested, "probably," as he says, "from visiting telegraph offices with a chum who had tastes similar to mine." He and this chum strung a line between their houses and learned the rudiments of writing by wire. Then a station master on the railroad, whose child Edison had saved from danger, took Edison under his wing and taught him the mysteries of railway telegraphy. The boy of sixteen held positions at small stations near home for a few months and then began a period of five years of apparently purposeless wandering as a tramp telegrapher. Toledo, Cincinnati, Indianapolis, Memphis, Louisville, Detroit, were some of the cities in which he worked, studied, experimented, and played practical jokes on his associates. He was eager to learn something of the principles of electricity but found few from whom he could learn.

Edison arrived in Boston in 1868, practically penniless, and applied for a position as night operator. "The manager asked me when I was ready

to go to work. 'Now,' I replied." In Boston he found men who knew something of electricity, and, as he worked at night and cut short his sleeping hours, he found time for study. He bought and studied Faraday's works. Presently came the first of his multitudinous inventions, an automatic vote recorder, for which he received a patent in 1868. This necessitated a trip to Washington, which he made on borrowed money, but he was unable to arouse any interest in the device. "After the vote recorder," he says, "I invented a stock ticker, and started a ticker service in Boston; had thirty or forty subscribers and operated from a room over the Gold Exchange." This machine Edison attempted to sell in New York, but he returned to Boston without having succeeded. He then invented a duplex telegraph by which two messages might be sent simultaneously, but at a test the machine failed because of the stupidity of the assistant.

Penniless and in debt, Edison arrived again in New York in 1869. But now fortune favored him. The Gold Indicator Company was a concern furnishing to its subscribers by telegraph the Stock Exchange prices of gold. The company's instrument was out of order. By a lucky chance Edison was on the spot to repair it, which he did successfully, and

this led to his appointment as superintendent at a salary of three hundred dollars a month. When a change in the ownership of the company threw him out of the position he formed, with Franklin L. Pope, the partnership of Pope, Edison, and Company, the first firm of electrical engineers in the United States.

Not long afterwards Edison brought out the invention which set him on the high road to great achievement. This was the improved stock ticker, for which the Gold and Stock Telegraph Company paid him forty thousand dollars. It was much more than he had expected. "I had made up my mind," he says, "that, taking into consideration the time and killing pace I was working at, I should be entitled to \$5000, but could get along with \$3000." The money, of course, was paid by check. Edison had never received a check before and he had to be told how to cash it.

Edison immediately set up a shop in Newark and threw himself into many and various activities. He remade the prevailing system of automatic telegraphy and introduced it into England. He experimented with submarine cables and worked out a system of quadruplex telegraphy by which one wire was made to do the work of four. These

two inventions were bought by Jay Gould for his Atlantic and Pacific Telegraph Company. Gould paid for the quadruplex system thirty thousand dollars, but for the automatic telegraph he paid nothing. Gould presently acquired control of the Western Union; and, having thus removed competition from his path, "he then," says Edison, "repudiated his contract with the automatic telegraph people and they never received a cent for their wires or patents, and I lost three years of very hard labor. But I never had any grudge against him because he was so able in his line, and as long as my part was successful the money with me was a secondary consideration. When Gould got the Western Union I knew no further progress in telegraphy was possible, and I went into other lines."¹

In fact, however, the need of money forced Edison later on to resume his work for the Western Union Telegraph Company, both in telegraphy and telephony. His connection with the telephone is told in another volume of this series.² He invented a carbon transmitter and sold it to the Western Union for one hundred thousand dollars, payable in seventeen annual installments of six thousand

¹ Quoted in Dyer and Martin, *Edison*, vol. 1, p. 164.

² Hendrick, *The Age of Big Business*.

dollars. He made a similar agreement for the same sum offered him for the patent of the electro-motograph. He did not realize that these installments were only simple interest upon the sums due him. These agreements are typical of Edison's commercial sense in the early years of his career as an inventor. He worked only upon inventions for which there was a possible commercial demand and sold them for a trifle to get the money to meet the pay rolls of his different shops. Later the inventor learned wisdom and associated with himself keen business men to their common profit.

Edison set up his laboratories and factories at Menlo Park, New Jersey, in 1876, and it was there that he invented the phonograph, for which he received the first patent in 1878. It was there, too, that he began that wonderful series of experiments which gave to the world the incandescent lamp. He had noticed the growing importance of open arc lighting, but was convinced that his mission was to produce an electric lamp for use within doors. Forsaking for the moment his newborn phonograph, Edison applied himself in earnest to the problem of the lamp. His first search was for a durable filament which would burn in a vacuum. A series of experiments with platinum wire and with various

refractory metals led to no satisfactory results. Many other substances were tried, even human hair. Edison concluded that carbon of some sort was the solution rather than a metal. Almost coincidentally, Swan, an Englishman, who had also been wrestling with this problem, came to the same conclusion. Finally, one day in October, 1879, after fourteen months of hard work and the expenditure of forty thousand dollars, a carbonized cotton thread sealed in one of Edison's globes lasted forty hours. "If it will burn **forty** hours now," said Edison, "I know I can make it burn a hundred." And so he did. A better filament was needed. Edison found it in carbonized strips of bamboo.

Edison developed his own type of dynamo, the largest ever made up to that time, and, along with the Edison incandescent lamps, it was one of the wonders of the Paris Electrical Exposition of 1881. The installation in Europe and America of plants for service followed. Edison's first great central station, supplying power for three thousand lamps, was erected at Holborn Viaduct, London, in 1882, and in September of that year the Pearl Street Station in New York City, the first central station in America, was put into operation.

The incandescent lamp and the central power

station, considered together, may be regarded as one of the most fruitful conceptions in the history of applied electricity. It comprised a complete generating, distributing, and utilizing system, from the dynamo to the very lamp at the fixture, ready for use. It even included a meter to determine the current actually consumed. The success of the system was complete, and as fast as lamps and generators could be produced they were installed to give a service at once recognized as superior to any other form of lighting. By 1885 the Edison lighting system was commercially developed in all its essentials, though still subject to many improvements and capable of great enlargement, and soon Edison sold out his interests in it and turned his great mind to other inventions.

The inventive ingenuity of others brought in time better and more economical incandescent lamps. From the filaments of bamboo fiber the next step was to filaments of cellulose in the form of cotton, duly prepared and carbonized. Later (1905) came the metalized carbon filament and finally the employment of tantalum or tungsten. The tungsten lamps first made were very delicate, and it was not until W. D. Coolidge, in the research laboratories of the General Electric Company at

Schenectady, invented a process for producing ductile tungsten that they became available for general use.

The dynamo and the central power station brought the electric motor into action. The dynamo and the motor do precisely opposite things. The dynamo converts mechanical energy into electric energy. The motor transforms electric energy into mechanical energy. But the two work in partnership and without the dynamo to manufacture the power the motor could not thrive. Moreover, the central station was needed to distribute the power for transportation as well as for lighting.

The first motors to use Edison station current were designed by Frank J. Sprague, a graduate of the Naval Academy, who had worked with Edison, as have many of the foremost electrical engineers of America and Europe. These small motors possessed several advantages over the big steam engine. They ran smoothly and noiselessly on account of the absence of reciprocating parts. They consumed current only when in use. They could be installed and connected with a minimum of trouble and expense. They emitted neither smell nor smoke.

Edison built an experimental electric railway line at Menlo Park in 1880 and proved its practicability. Meanwhile, however, as he worked on his motors and dynamos, he was anticipated by others in some of his inventions. It would not be fair to say that Edison and Sprague alone developed the electric railway, for there were several others who made important contributions. Stephen D. Field of Stockbridge, Massachusetts, had a patent which the Edison interests found it necessary to acquire; C. J. Van Depoele and Leo Daft made important contributions to the trolley system. In Cleveland in 1884 an electric railway on a small scale was opened to the public. But Sprague's first electric railway, built at Richmond, Virginia, in 1887, as a complete system, is generally hailed as the true pioneer of electric transportation in the United States. Thereafter the electric railway spread quickly over the land, obliterating the old horse-cars and greatly enlarging the circumference of the city. Moreover, on the steam roads, at all the great terminals, and wherever there were tunnels to be passed through, the old giant steam engine in time yielded place to the electric motor.

The application of the electric motor to the "vertical railway," or elevator, made possible the steel

skyscraper. The elevator, of course, is an old device. It was improved and developed in America by Elisha Graves Otis, an inventor who lived and died before the Civil War and whose sons afterward erected a great business on foundations laid by him. The first Otis elevators were moved by steam or hydraulic power. They were slow, noisy, and difficult of control. After the electric motor came in, the elevator soon changed its character and adapted itself to the imperative demands of the towering, skeleton-framed buildings which were rising in every city.

Edison, already famous as "the Wizard of Menlo Park," established his factories and laboratories at West Orange, New Jersey, in 1887, whence he has since sent forth a constant stream of inventions, some new and startling, others improvements on old devices. The achievements of several other inventors in the electrical field have been only less noteworthy than his. The new profession of electrical engineering called to its service great numbers of able men. Manufacturers of electrical machinery established research departments and employed inventors. The times had indeed changed since the day when Morse, as a student at Yale College, chose art instead of electricity as his

calling, because electricity afforded him no means of livelihood.

From Edison's plant in 1903 came a new type of the storage battery, which he afterwards improved. The storage battery, as every one knows, is used in the propulsion of electric vehicles and boats, in the operation of block-signals, in the lighting of trains, and in the ignition and starting of gasoline engines. As an adjunct of the gas-driven automobile, it renders the starting of the engine independent of muscle and so makes possible the general use of the automobile by women as well as men.

The dynamo brought into service not only light and power but heat; and the electric furnace in turn gave rise to several great metallurgical and chemical industries. Elihu Thomson's process of welding by means of the arc furnace found wide and varied applications. The commercial production of aluminum is due to the electric furnace and dates from 1886. It was in that year that H. Y. Castner of New York and C. M. Hall of Pittsburgh both invented the methods of manufacture which gave to the world the new metal, malleable and ductile, exceedingly light, and capable of a thousand uses. Carborundum is another product of the electric furnace. It was the invention of Edward

B. Acheson, a graduate of the Edison laboratories. Acheson, in 1891, was trying to make artificial diamonds and produced instead the more useful carborundum, as well as the Acheson graphite, which at once found its place in industry. Another valuable product of the electric furnace was the calcium carbide first produced in 1892 by **Thomas L. Wilson** of Spray, North Carolina. This calcium carbide is the basis of acetylene gas, a powerful illuminant, and it is widely used in metallurgy, for welding and other purposes.

At the same time with these developments the value of the alternating current came to be recognized. The transformer, an instrument developed on foundations laid by **Henry** and **Faraday**, made it possible to transmit electrical energy over great distances with little loss of power. Alternating currents were transformed by means of this instrument at the source, and were again converted at the point of use to a lower and convenient potential for local distribution and consumption. The first extensive use of the alternating current was in arclighting, where the higher potentials could be employed on series lamps. Perhaps the chief American inventor in the domain of the alternating current is **Elihu Thomson**, who began his useful career as

Professor of Chemistry and Mechanics in the Central High School of Philadelphia. Another great protagonist of the alternating current was George Westinghouse, who was quite as much an improver and inventor as a manufacturer of machinery. Two other inventors, at least, should not be forgotten in this connection: Nicola Tesla and Charles S. Bradley. Both of them had worked for Edison.

The turbine (from the Latin *turbo*, meaning a whirlwind) is the name of the motor which drives the great dynamos for the generation of electric energy. It may be either a steam turbine or a water turbine. The steam turbine of Curtis or Parsons is today the prevailing engine. But the development of hydro-electric power has already gone far. It is estimated that the electric energy produced in the United States by the utilization of water powers every year equals the power product of forty million tons of coal, or about one-tenth of the coal which is consumed in the production of steam. Yet hydro-electricity is said to be only in its beginnings, for not more than a tenth of the readily available water power of the country is actually in use.

The first commercial hydro-station for the transmission of power in America was established in

1891 at Telluride, Colorado. It was practically duplicated in the following year at Brodie, Colorado. The motors and generators for these stations came from the Westinghouse plant in Pittsburgh, and Westinghouse also supplied the turbo-generators which inaugurated, in 1895, the delivery of power from Niagara Falls.

CHAPTER X

THE CONQUEST OF THE AIR

THE most popular man in Europe in the year 1783 was still the United States Minister to France. The figure of plain Benjamin Franklin, his broad head, with the calm, shrewd eyes peering through the bifocals of his own invention, invested with a halo of great learning and fame, entirely captivated the people's imagination.

As one of the American Commissioners busy with the extraordinary problems of the Peace, Franklin might have been supposed too occupied for excursions into the paths of science and philosophy. But the spaciousness and orderly furnishing of his mind provided that no pursuit of knowledge should be a digression for him. So we find him, naturally, leaving his desk on several days of that summer and autumn and posting off to watch the trials of a new invention; nothing less indeed than a ship to ride the air. He found time also to

describe the new invention in letters to his friends in different parts of the world.

On the 21st of November Franklin set out for the gardens of the King's hunting lodge in the Bois de Boulogne, on the outskirts of Paris, with a quickened interest, a thrill of excitement, which made him yearn to be young again with another long life to live that he might see what should be after him on the earth. What bold things men would attempt! Today two daring Frenchmen, Pilâtre de Rozier of the Royal Academy and his friend the Marquis d'Arlandes, would ascend in a balloon freed from the earth — the first men in history to adventure thus upon the wind. The crowds gathered to witness the event opened a lane for Franklin to pass through.

At six minutes to two the aeronauts entered the car of their balloon; and, at a height of two hundred and seventy feet, doffed their hats and saluted the applauding spectators. Then the wind carried them away toward Paris. Over Passy, about half a mile from the starting point, the balloon began to descend, and the River Seine seemed rising to engulf them; but when they fed the fire under their sack of hot air with chopped straw they rose to the elevation of five hundred feet. Safe across the

river they dampened the fire with a sponge and made a gentle descent beyond the old ramparts of Paris.

At five o'clock that afternoon, at the King's Château in the Bois de Boulogne, the members of the Royal Academy signed a memorial of the event. One of the spectators accosted Franklin.

"What does Dr. Franklin conceive to be the use of this new invention?"

"What is the use of a new-born child?" was the retort.

A new-born child, a new-born republic, a new invention: alike dim beginnings of development which none could foretell. The year that saw the world acknowledge a new nation, freed of its ancient political bonds, saw also the first successful attempt to break the supposed bonds that held men down to the ground. Though the invention of the balloon was only five months old, there were already two types on exhibition: the original Montgolfier, or fire-balloon, inflated with hot air, and a modification by Charles, inflated with hydrogen gas. The mass of the French people did not regard these balloons with Franklin's serenity. Some weeks earlier the danger of attack had necessitated a balloon's removal from the place of its first moorings

to the Champ de Mars at dead of night. Preceded by flaming torches, with soldiers marching on either side and guards in front and rear, the great ball was borne through the darkened streets. The midnight cabby along the route stopped his nag, or tumbled from sleep on his box, to kneel on the pavement and cross himself against the evil that might be in that strange monster. The fear of the people was so great that the Government saw fit to issue a proclamation, explaining the invention. Any one seeing such a globe, like the moon in an eclipse, so read the proclamation, should be aware that it is only a bag made of taffeta or light canvas covered with paper and "cannot possibly cause any harm and which will some day prove serviceable to the wants of society."

Franklin wrote a description of the Montgolfier balloon to Sir Joseph Banks, President of the Royal Society of London:

Its bottom was open and in the middle of the opening was fixed a kind of basket grate, in which faggots and sheaves of straw were burnt. The air, rarefied in passing through this flame, rose in the balloon, swelled out its sides, and filled it. The persons, who were placed in the gallery made of wicker and attached to the outside near the bottom, had each of them a port through which they could pass sheaves of straw into

the grate to keep up the flame and thereby keep the balloon full. . . . One of these courageous philosophers, the Marquis d'Arlandes, did me the honor to call upon me in the evening after the experiment, with Mr. Montgolfier, the very ingenious inventor. I was happy to see him safe. He informed me that they lit gently, without the least shock, and the balloon was very little damaged.

Franklin writes that the competition between Montgolfier and Charles has already resulted in progress in the construction and management of the balloon. He sees it as a discovery of great importance, one that "may possibly give a new turn to human affairs. Convincing sovereigns of the folly of war may perhaps be one effect of it, since it will be impracticable for the most potent of them to guard his dominions." The prophecy may yet be fulfilled. Franklin remarks that a short while ago the idea of "witches riding through the air upon a broomstick and that of philosophers upon a bag of smoke would have appeared equally impossible and ridiculous." Yet in the space of a few months he has seen the philosopher on his smoke bag, if not the witch on her broom. He wishes that one of these very ingenious inventors would immediately devise means of direction for the balloon, a rudder to steer it; because the malady from which he is

suffering is always increased by a jolting drive in a fourwheeler and he would gladly avail himself of an easier way of locomotion.

The vision of man on the wing did not, of course, begin with the invention of the balloon. Perhaps the dream of flying man came first to some primitive poet of the Stone Age, as he watched, fearfully, the gyrations of the winged creatures of the air; even as in a later age it came to Langley and Maxim, who studied the wing motions of birds and insects, not in fear but in the light and confidence of advancing science.

Crudely outlined by some ancient Egyptian sculptor, a winged human figure broods upon the tomb of Rameses III. In the Hebrew parable of Genesis winged cherubim guarded the gates of Paradise against the man and woman who had stifled aspiration with sin. Fairies, witches, and magicians ride the wind in the legends and folklore of all peoples. The Greeks had gods and goddesses many; and one of these Greek art represents as moving earthward on great spreading pinions. Victory came by the air. When Demetrius, King of Macedonia, set up the Winged Victory of Samothrace to commemorate the naval triumph of the

Greeks over the ships of Egypt, Greek art poetically foreshadowed the relation of the air service to the fleet in our own day.

Man has always dreamed of flight; but when did men first actually fly? We smile at the story of Daedalus, the Greek architect, and his son, Icarus, who made themselves wings and flew from the realm of their foes; and the tale of Simon, the magician, who pestered the early Christian Church by exhibitions of flight into the air amid smoke and flame in mockery of the ascension. But do the many tales of sorcerers in the Middle Ages, who rose from the ground with their cloaks apparently filled with wind, to awe the rabble, suggest that they had deduced the principle of the aerostat from watching the action of smoke as did the Montgolfiers hundreds of years later? At all events one of these alleged exhibitions about the year 800 inspired the good Bishop Agobard of Lyons to write a book against superstition, in which he proved conclusively that it was impossible for human beings to rise through the air. Later, Roger Bacon and Leonardo da Vinci, each in his turn ruminated in manuscript upon the subject of flight. Bacon, the scientist, put forward a theory of thin copper globes filled with liquid fire, which would soar. Leonardo,

artist, studied the wings of birds. The Jesuit Francisco Lana, in 1670, working on Bacon's theory sketched an airship made of four copper balls with a skiff attached; this machine was to soar by means of the lighter-than-air globes and to be navigated aloft by oars and sails.

But while philosophers in their libraries were designing airships on paper and propounding their theories, venturesome men, "crawling, but pestered with the thought of wings," were making pinions of various fabrics and trying them upon the wind. Four years after Lana suggested his airship with balls and oars, Besnier, a French locksmith, made a flying machine of four collapsible planes like book covers suspended on rods. With a rod over each shoulder, and moving the two front planes with his arms and the two back ones by his feet, Besnier gave exhibitions of gliding from a height to the earth. But his machine could not soar. What may be called the first patent on a flying machine was recorded in 1709 when Bartholomeo de Gusmao, a friar, appeared before the King of Portugal to announce that he had invented a flying machine and to request an order prohibiting other men from making anything of the sort. The King decreed pain of death to all infringers; and to

assist the enterprising monk in improving his machine, he appointed him first professor of mathematics in the University of Coimbra with a fat stipend. Then the Inquisition stepped in. The inventor's suave reply, to the effect that to show men how to soar to Heaven was an essentially religious act, availed him nothing. He was pronounced a sorcerer, his machine was destroyed, and he was imprisoned till his death. Many other men fashioned unto themselves wings; but, though some of them might glide earthward, none could rise upon the wind.

While the principle by which the balloon, father of the dirigible, soars and floats could be deduced by men of natural powers of observation and little science from the action of clouds and smoke, the airplane, the Winged Victory of our day, waited upon two things—the scientific analysis of the anatomy of bird wings and the internal combustion engine.

These two things necessary to convert man into a rival of the albatross did not come at once and together. Not the dream of flying but the need for quantity and speed in production to take care of the wants of a modern civilization compelled the invention of the internal combustion engine. Before it appeared in the realm of mechanics,

experimenters were applying in the construction of flying models the knowledge supplied by Cayley in 1796, who made an instrument of whalebone, corks, and feathers, which by the action of two screws of quill feathers, rotating in opposite directions, would rise to the ceiling; and the full revelation of the structure and action of bird wings set forth by Pettigrew in 1867.

“The wing, both when at rest and when in motion,” Pettigrew declared, “may not inaptly be compared to the blade of an ordinary screw propeller as employed in navigation. Thus the general outline of the wing corresponds closely with the outline of the propeller, and the track described by the wing in space *is twisted upon itself* propeller fashion.” Numerous attempts to apply the newly discovered principles to artificial birds failed, yet came so close to success that they fed instead of killing the hope that a solution of the problem would one day ere long be reached.

“Nature has solved it, and why not man?”

From his boyhood days Samuel Pierpont Langley, so he tells us, had asked himself that question, which he was later to answer. Langley, born in Roxbury, Massachusetts, in 1834, was another link

in the chain of distinguished inventors who first saw the light of day in Puritan New England. And, like many of those other inventors, he numbered among his ancestors for generations two types of men — on the one hand, a line of skilled artisans and mechanics; on the other, the most intellectual men of their time such as clergymen and schoolmasters, one of them being Increase Mather. We see in Langley, as in some of his brother New England inventors, the later flowering of the Puritan ideal stripped of its husk of superstition and harshness — a high sense of duty and of integrity, an intense conviction that the reason for a man's life here is that he may give service, a reserved deportment which did not mask from discerning eyes the man's gentle qualities of heart and his keen love of beauty in art and Nature.

Langley first chose as his profession civil engineering and architecture and the years between 1857 and 1864 were chiefly spent in prosecuting these callings in St. Louis and Chicago. Then he abandoned them; for the bent of his mind was definitely towards scientific inquiry. In 1867 he was appointed director of the Allegheny Observatory at Pittsburgh. Here he remained until 1887, when, having made for himself a world-wide

reputation as an astronomer, he became Secretary of the Smithsonian Institution at Washington.

It was about this time that he began his experiments in "aerodynamics." But the problem of flight had long been a subject of interested speculation with him. Ten years later he wrote:

Nature has made her flying-machine in the bird, which is nearly a thousand times as heavy as the air its bulk displaces, and only those who have tried to rival it know how inimitable her work is, for the "way of a bird in the air" remains as wonderful to us as it was to Solomon, and the sight of the bird has constantly held this wonder before men's minds, and kept the flame of hope from utter extinction, in spite of long disappointment. I well remember how, as a child, when lying in a New England pasture, I watched a hawk soaring far up in the blue, and sailing for a long time without any motion of its wings, as though it needed no work to sustain it, but was kept up there by some miracle. But, however sustained, I saw it sweep in a few seconds of its leisurely flight, over a distance that to me was encumbered with every sort of obstacle, which did not exist for it. . . . How wonderfully easy, too, was its flight! There was not a flutter of its pinions as it swept over the field, in a motion which seemed as effortless as that of its shadow. After many years and in mature life, I was brought to think of these things again, and to ask myself whether the problem of artificial flight was as hopeless and as absurd as it was then thought to be.

In three or four years Langley made nearly forty models. "The primary difficulty lay in making the model light enough and sufficiently strong to support its power," he says. "This difficulty continued to be fundamental through every later form; but, beside this, the adjustment of the center of gravity to the center of pressure of the wings, the disposition of the wings themselves, the size of the propellers, the inclination and number of the blades, and a great number of other details, presented themselves for examination."

By 1891 Langley had a model light enough to fly, but proper balancing had not been attained. He set himself anew to find the practical conditions of equilibrium and of horizontal flight. His experiments convinced him that "mechanical sustentation of heavy bodies in the air, combined with very great speeds, is not only possible, but within the reach of mechanical means we actually possess."

After many experiments with new models Langley at length fashioned a steam-driven machine which would fly horizontally. It weighed about thirty pounds; it was some sixteen feet in length, with two sets of wings, the pair in front measuring forty feet from tip to tip. On May 6, 1896, this model was launched over the Potomac River. It

flew half a mile in a minute and a half. When its fuel and water gave out, it descended gently to the river's surface. In November Langley launched another model which flew for three-quarters of a mile at a speed of thirty miles an hour. These tests demonstrated the practicability of artificial flight.

The Spanish-American War found the military observation balloon doing the limited work which it had done ever since the days of Franklin. President McKinley was keenly interested in Langley's design to build a power-driven flying machine which would have innumerable advantages over the balloon. The Government provided the funds and Langley took up the problem of a flying machine large enough to carry a man. His initial difficulty was the engine. It was plain at once that new principles of engine construction must be adopted before a motor could be designed of high power yet light enough to be borne in the slender body of an airplane. The internal combustion engine had now come into use. Langley went to Europe in 1900, seeking his motor, only to be told that what he sought was impossible.

His assistant, Charles M. Manly, meanwhile found a builder of engines in America who was willing to make the attempt. But, after two years

of waiting for it, the engine proved a failure. Manly then had the several parts of it, which he deemed hopeful, transported to Washington, and there at the Smithsonian Institution he labored and experimented until he evolved a light and powerful gasoline motor. In October, 1903, the test was made, with Manly aboard of the machine. The failure which resulted was due solely to the clumsy launching apparatus. The airplane was damaged as it rushed forward before beginning to soar; and, as it rose, it turned over and plunged into the river. The loyal and enthusiastic Manly, who was fortunately a good diver and swimmer, hastily dried himself and gave out a reassuring statement to the representatives of the press and to the officers of the Board of Ordnance gathered to witness the flight.

A second failure in December convinced spectators that man was never intended to fly. The newspapers let loose such a storm of ridicule upon Langley and his machine, with charges as to the waste of public funds, that the Government refused to assist him further. Langley, at that time sixty-nine years of age, took this defeat so keenly to heart that it hastened his death, which occurred three years later. "Failure in the aerodrome itself,"

he wrote, "or its engines there has been none; and it is believed that it is at the moment of success, and when the engineering problems have been solved, that a lack of means has prevented a continuance of the work."

It was truly "at the moment of success" that Langley's work was stopped. On December 17, 1903, the Wright brothers made the first successful experiment in which a machine carrying a man rose by its own power, flew naturally and at even speed, and descended without damage. These brothers, Wilbur and Orville, who at last opened the long besieged lanes of the air, were born in Dayton, Ohio. Their father, a clergyman and later a bishop, spent his leisure in scientific reading and in the invention of a typewriter which, however, he never perfected. He inspired an interest in scientific principles in his boys' minds by giving them toys which would stimulate their curiosity. One of these toys was a helicopter, or Cayley's Top, which would rise and flutter awhile in the air.

After several helicopters of their own, the brothers made original models of kites, and Orville, the younger, attained an exceptional skill in flying them. Presently Orville and Wilbur were making

their own bicycles and astonishing their neighbors by public appearances on a specially designed tandem. The first accounts which they read of experiments with flying machines turned their inventive genius into the new field. In particular the newspaper accounts at that time of Otto Lilienthal's exhibitions with his glider stirred their interest and set them on to search the libraries for literature on the subject of flying. As they read of the work of Langley and others they concluded that the secret of flying could not be mastered theoretically in a laboratory; it must be learned in the air. It struck these young men, trained by necessity to count pennies at their full value, as "wasteful extravagance" to mount delicate and costly machinery on wings which no one knew how to manage. They turned from the records of other inventors' models to study the one perfect model, the bird. Said Wilbur Wright, speaking before the Society of Western Engineers, at Chicago:

The bird's wings are undoubtedly very well designed indeed, but it is not any extraordinary efficiency that strikes with astonishment, but rather the marvelous skill with which they are used. It is true that I have seen birds perform soaring feats of almost incredible nature in positions where it was not possible to measure the speed and trend of the wind, but whenever it

was possible to determine by actual measurements the conditions under which the soaring was performed it was easy to account for it on the basis of the results obtained with artificial wings. The soaring problem is apparently not so much one of better wings as of better operators.¹

When the Wrights determined to fly, two problems which had beset earlier experimenters had been partially solved. Experience had brought out certain facts regarding the wings; and invention had supplied an engine. But the laws governing the balancing and steering of the machine were unknown. The way of a man in the air had yet to be discovered.

The starting point of their theory of flight seems to have been that man was endowed with an intelligence at least equal to that of the bird; and, that with practice he could learn to balance himself in the air as naturally and instinctively as on the ground. He must and could be, like the bird, the controlling intelligence of his machine. To quote Wilbur Wright again:

It seemed to us that the main reason why the problem had remained so long unsolved was that no one had been able to obtain any adequate practice. Lilienthal, in five years of time, had spent only five hours

¹ Cited in Turner, *The Romance of Aeronautics*.

in actual gliding through the air. The wonder was not that he had done so little but that he had accomplished so much. It would not be considered at all safe for a bicycle rider to attempt to ride through a crowded city street after only five hours' practice spread out in bits of ten seconds each over a period of five years, yet Lilienthal with his brief practice was remarkably successful in meeting the fluctuations and eddies of wind-gusts. We thought that if some method could be found by which it would be possible to practice by the hour instead of by the second, there would be a hope of advancing the solution of a very difficult problem.

The brothers found that winds of the velocity they desired for their experiments were common on the coast of North Carolina. They pitched their camp at Kitty Hawk in October, 1900, and made a brief and successful trial of their gliding machine. Next year, they returned with a much larger machine; and in 1902 they continued their experiments with a model still further improved from their first design. Having tested their theories and become convinced that they were definitely on the right track, they were no longer satisfied merely to glide. They set about constructing a power machine. Here a new problem met them. They had decided on two screw propellers rotating in opposite directions on the principle of wings in

flight; but the proper diameter, pitch, and area of blade were not easily arrived at.

On December 17, 1903, the first Wright biplane was ready to navigate the air and made four brief successful flights. Subsequent flights in 1904 demonstrated that the problem of equilibrium had not been fully solved; but the experiments of 1905 banished this difficulty.

The responsibility which the Wrights placed upon the aviator for maintaining his equilibrium, and the tailless design of their machine, caused much headshaking among foreign flying men when Wilbur Wright appeared at the great aviation meet in France in 1908. But he won the Michelin Prize of eight hundred pounds by beating previous records for speed and for the time which any machine had remained in the air. He gave exhibitions also in Germany and Italy and instructed Italian army officers in the flying of Wright machines. At this time Orville was giving similar demonstrations in America. Transverse control, the warping device invented by the Wright brothers for the preservation of lateral balance and for artificial inclination in making turns, has been employed in a similar or modified form in most airplanes since constructed.

There was no "mine" or "thine" in the diction

of the Wright brothers; only "we" and "ours." They were joint inventors; they shared their fame equally and all their honors and prizes also until the death of Wilbur in 1912. They were the first inventors to make the ancient dream of flying man a reality and to demonstrate that reality to the practical world.

When the NC flying boats of the United States navy lined up at Trepassey in May, 1919, for their Atlantic venture, and the press was full of pictures of them, how many hasty readers, eager only for news of the start, stopped to think what the initials NC stood for?

The seaplane is the chief contribution of Glenn Hammond Curtiss to aviation, and the Navy Curtiss Number Four, which made the first transatlantic flight in history, was designed by him. The spirit of coöperation, expressed in pooling ideas and fame, which the Wright brothers exemplified, is seen again in the association of Curtiss with the navy during the war. NC is a fraternity badge signifying equal honors.

Curtiss, in 1900, was — like the Wrights — the owner of a small bicycle shop. It was at Hammondsport, New York. He was an enthusiastic

cyclist, and speed was a mania with him. He evolved a motor cycle with which he broke all records for speed over the ground. He started a factory and achieved a reputation for excellent motors. He designed and made the engine for the dirigible of Captain Thomas S. Baldwin; and for the first United States army dirigible in 1905.

Curtiss carried on some of his experiments in association with Alexander Graham Bell, who was trying to evolve a stable flying machine on the principle of the cellular kite. Bell and Curtiss, with three others, formed in 1907, the Aerial Experimental Association at Bell's country house in Canada, which was fruitful of results, and Curtiss scored several notable triumphs with the craft they designed. But the idea of a machine which could descend and propel itself on water possessed his mind, and in 1911 he exhibited at the aviation meet in Chicago the hydroaeroplane. An incident there set him dreaming of the life-saving systems on great waters. His hydroaeroplane had just returned to its hangar, after a series of maneuvers, when a monoplane in flight broke out of control and plunged into Lake Michigan. The Curtiss machine left its hangar on the minute, covered the intervening mile, and alighted on the water to offer

aid. The presence of boats made the good offices of the hydroaeroplane unnecessary on that occasion; but the incident opened up to the mind of Curtiss new possibilities.

In the first years of the World War Curtiss built airplanes and flying boats for the Allies. The United States entered the arena and called for his services. The Navy Department called for the big flying boat; and the NC type was evolved, which, equipped with four Liberty Motors, crossed the Atlantic after the close of the war.

The World War, of course, brought about the magical development of all kinds of air craft. Necessity not only mothered invention but forced it to cover a normal half century of progress in four years. While Curtiss worked with the navy, the Dayton-Wright factory turned out the famous DH fighting planes under the supervision of Orville Wright. The second initial here stands for Haviland, as the DH was designed by Geoffrey de Haviland, a British inventor.

The year 1919 saw the first transatlantic flights. The NC4, with Lieutenant Commander Albert Cushing Read and crew, left Trepassey, Newfoundland, on the 16th of May and in twelve hours arrived at Horta, the Azores, more than a thousand

miles away. All along the course the navy had strung a chain of destroyers, with signaling apparatus and searchlights to guide the aviators. On the twenty-seventh, NC4 took off from San Miguel, Azores, and in nine hours made Lisbon — Lisbon, capital of Portugal, which sent out the first bold mariners to explore the Sea of Darkness, prior to Columbus. On the thirtieth, NC4 took off for Plymouth, England, and arrived in ten hours and twenty minutes. Perhaps a phantom ship, with sails set and flags blowing, the name *Mayflower* on her hull, rode in Plymouth Harbor that day to greet a New England pilot.

On the 14th of June the Vickers-Vimy Rolls-Royce biplane, piloted by John Alcock and with Arthur Whitten Brown as observer-navigator, left St. John's, Newfoundland, and arrived at Clifden, Ireland, in sixteen hours twelve minutes, having made the first non-stop transatlantic flight. Hawker and Grieve meanwhile had made the same gallant attempt in a single-engined Sopwith machine; and had come down in mid-ocean, after flying fourteen and a half hours, owing to the failure of their water circulation. Their rescue by slow Danish *Mary* completed a fascinating tale of heroic adventure.

The British dirigible R34, with Major G. H. Scott in command, left East Fortune, Scotland, on the 2d of July, and arrived at Mineola, New York, on the sixth. The R34 made the return voyage in seventy-five hours. In November, 1919, Captain Sir Ross Smith set off from England in a biplane to win a prize of ten thousand pounds offered by the Australian Commonwealth to the first Australian aviator to fly from England to Australia in thirty days. Over France, Italy, Greece, over the Holy Land, perhaps over the Garden of Eden, whence the winged cherubim drove Adam and Eve, over Persia, India, Siam, the Dutch East Indies to Port Darwin in northern Australia; and then south-eastward across Australia itself to Sydney, the biplane flew without mishap. The time from Hounslow, England, to Port Darwin was twenty-seven days, twenty hours, and twenty minutes. Early in 1920 the Boer airman Captain Van Ryneveld made the flight from Cairo to the Cape.

Commercial development of the airplane and the airship commenced after the war. The first air service for United States mails was, in fact, inaugurated during the war, between New York and Washington. The transcontinental service was established soon afterwards, and a regular line

between Key West and Havana. French and British companies began to operate daily between London and Paris carrying passengers and mail. Airship companies were formed in Australia, South Africa, and India. In Canada airplanes were soon being used in prospecting the Labrador timber regions, in making photographs and maps of the northern wilderness, and by the Northwest Mounted Police.

It is not for history to prophesy. "Emblem of much, and of our Age of Hope itself," Carlyle called the balloon of his time, born to mount majestically but "unguidably" only to tumble "whither Fate will." But the air craft of our day is guidable, and our Age of Hope is not rudderless nor at the mercy of Fate.



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INDEX

- Acheson, E. B., invents carborundum, 216-17
- Adams, Henry, *History of the United States*, quoted, 111
- Adams, J. Q., and Morse, 136; and Eli Whitney, 184
- Aerial Experimental Association, 241
- Aerial navigation, 220 *et seq.*; bibliography, 254
- Aeroplanes, *see* Aerial navigation, Airplanes
- Agobard, Bishop, writes to prove impossibility of flying, 226
- Agricultural machinery, bibliography, 250; *see also* Agricultural revolution, names of implements
- Agricultural revolution, 110 *et seq.*
- Airplanes, 225 *et seq.*; *see also* Aerial navigation
- Albany Conference, 16
- Alcock, John, transatlantic flight, 243
- Alexander the Great introduces cotton into Europe, 32
- Alexanderson, and wireless telegraphy, 146
- Allen, Horatio, brings locomotive from England, 78
- Allston, Washington, American artist, and Morse, 132-133, 136
- Almy, William, partner of Moses Brown, 86, 87
- Aluminum, 216
- American Philosophical Society, 14
- American Turtle*, submarine, 64 (note)
- Ampère, A. M., French investigator of electricity, 195
- Appleby, J. F., invents binder, 119
- Appleton, Nathan, Boston merchant, 89; and Lowell enterprise, 90, 91, 92
- Arkwright, Richard, invents water-frame, 35; looms introduced into New England, 97
- Arlandes, Marquis d', first balloon flight, 221; and Franklin, 224
- Arms, *see* Firearms
- Automobiles, 202; storage battery, 216
- Bachelder, John, and sewing machine, 104
- Bacon, Roger, on subject of flight, 226
- Bailey, Jeremiah, invents mower, 121
- Baily, Francis, patent for punches for type, 29
- Baldwin, Matthias, locomotives, 82
- Baldwin, Captain T. S., dirigible, 241
- Balloons, 221-25
- Baltimore, Democratic National Convention (1844) uses telegraph, 143-44

- Baltimore and Ohio Railroad, 80
- Banks, Sir Joseph, Franklin's letter to, 223-24
- Banks, N. P., cousin of Elias Howe, 99
- Barlow, Joel, and Fulton, 63
- Barnard, Henry, *Armsmear*, quoted, 191
- Bayard, William, at Castle Point, 177
- Beach, A. E., typewriter, 150; device for embossing letters for blind, 150
- Bell, A. G., telephone, 146, 196; and Henry, 201-02; Aerial Experimental Association, 241
- Bell, Patrick, invents reaper, 116
- Besnier, invents flying machine, 227
- Best Friend of Charleston*, locomotive, 80
- Binders, 119-20
- Blake, L. B., sole-sewing machine, 108
- Blanchard, Thomas, inventor of machine tools, 185-87; bibliography, 253
- Blenkinsop, steam railway experiments, 78
- Bliss, G. W., Elias Howe and, 103
- Boott, Kirk, partner in Lowell mills, 91
- Boston, Franklin's home in, 1-3; Franklin visits, 9
- Boulton, Matthew, associate of Watt, 55, 56
- Braddock, General, Franklin and, 16-17
- Bradford, William, printer in New York, 3
- Bradley, C. S., electrical inventor, 218
- Braithwaite, John, locomotive race, 79
- Bridgewater, Francis, Duke of, and Fulton, 62
- Brindley, James, and Fulton, 62
- Brodie (Colorado), hydro-station at, 219
- Brown, A. W., transatlantic flight, 243
- Brown, Moses, and spinning machine, 86, 87
- Brush, C. F., electric lighting, 203
- Burt, William, typewriter, 150
- Bushnell, David, invents submarine, 64 (note)
- Cable, Atlantic, 145-46; bibliography, 251
- Calcium carbide, 217
- Calhoun, J. C., Lowell and, 90
- California, market for clothing, 107
- Camden and Amboy Railroad, 80, 178
- Camera, *see* Photography
- Candles, patent for method of making, 29
- Carborundum, 216-17
- Cartwright, Edmund, invents self-acting loom, 36, 97
- Castle Point, Stevens's home at, 177
- Castner, H. Y., aluminum manufacture, 216
- Cavendish, Henry, English investigator of electricity, 195
- Cayley, Sir George, principles of flying, 229
- Center, Joab, hay spreader, 122
- Chambers's Encyclopædia* as newspaper feature, 6
- Charles, J. A. C., French inventor of balloon, 222, 224
- Charleston and Hamburg Railroad, 80

- Charlotte Dundas*, steamboat, 65
- Chicago, McCormick in, 118
- Choate, Rufus, Goodyear *vs.* Day, 157
- Circulation of blood, Harvey discovers, 12 (note)
- Civil War, marks beginning of new period in industry, 124
- Clermont*, Fulton's steamboat, 60, 65-67, 68
- Cleveland, first electric lighting in, 203
- Clocks, pendulum clocks in Middle Ages, 12 (note)
- Clothing, manufacture of, 106-107
- Clymer, George, Columbian press, 147
- Collinson, Peter, and Franklin, 9-10
- Colt, Samuel, revolver, 187-189; arms factory, 190-91; bibliography, 253
- Commerce at end of 18th century, 25-26
- Communication, Agents of, 128 *et seq.*; bibliography, 251; *see also* Transportation
- Compass, Mariner's. ancients know of, 12 (note)
- Congress, first Patent Act (1790), 27-30, 176; second Patent Act (1793), 30-31; Evans petitions for extension of patent, 72-73; Morse petitions for appropriation, 139, 141
- Coolidge, W. D., ductile tungs-ten, 212-13
- Cooper, J. F., attack on Adams, 136
- Cooper, Peter, designs loco-motive, 80; Atlantic Cable, 145-46
- Corliss, G. H., engine, 83
- Corn-binders, 122
- Corn-shellors, 122-23
- Cornell, Ezra, telegraph con-struction, 142-43, 144
- Cotton, history of use, 32-33; introduced into colonies, 33-34; difficulties in cleaning of, 34-35; inventions for manu-facture of, 35-36; *see also* Cotton gin, Cotton manu-facture, Textile industry
- Cotton gin, patented, 30-31; Eli Whitney and, 32 *et seq.*; infringements of patent, 44; influence, 84; and Civil War, 124; effect on South, 125; bibliography, 248-49
- Cotton manufacture, bibli-ography, 249-50; *see also* Textile industry
- Coulomb, C. A. de, French in-vestigator of electricity, 195
- Courtenay, Viscount, and Ful-ton, 62
- Crompton, Samuel, invents mule, 35
- Cumberland Road, 77
- Curtis, Harriot ("Mina Myrtle"), in Lowell mills, 93
- Curtis, steam turbine, 218
- Curtiss, G. H., airplanes, 240-242
- Daft, Leo, contribution to trolley system, 214
- Daguerre, L. J. M., and pho-tography, 140
- Dana, J. F., and Morse, 134
- Davenport, Thomas, pioneer of automobile in America, 202
- Davis, Ari, Howe in shop of, 99
- Davis, Jefferson, on Whitney's rifles, 183
- Day, Jeremiah, and Morse, 130-31
- Deere, John, ploughs, 113
- Deering, William, competitor of McCormick, 119

- De Forest, Lee, wireless telegraphy, 146
- Densmore, James, typewriter, 151, 152
- De Witt Clinton*, locomotive, 81
- Dickens, Charles, visits Lowell, 94; *American Notes*, quoted, 94-96
- Dinwiddie, Governor of Virginia, problem of funds for defense, 16
- Draper, J. W., photography, 140, 153
- Drills, 115
- Du Fay, French investigator of electricity, 195
- Dulles, J. M., letter describing Morse, 131-32
- Dyer and Martin, *Edison*, quoted, 209
- East Bridgewater (Massachusetts), spinning machine made in, 85
- East India Company import cotton fabrics, 32-33
- Eastman, George, kodak, 153-154
- Eastman Company, introduces film cartridge, 154; motion picture films, 155
- Eaton, Theophilus, Goodyear's ancestor associated with, 165
- Edison, John, grandfather of T. A., 204
- Edison, Samuel, father of T. A., 204
- Edison, T. A., 196; phonograph, 152, 210; motion pictures, 154; "kinetoscope," 155; antecedents, 203-04; birth (1847), 204; boyhood, 204-06; tramp telegrapher, 206; in Boston, 206-07; automatic vote recorder, 207; stock ticker, 207; duplex telegraph, 207; goes to New York, 207; firm of Pope, Edison, and Company; 208; improved stock ticker, 208; shop in Newark, 208; automatic telegraph, 208, 209; cable experiments, 208; quadruple telegraph, 208, 209; district messenger call-box system, 209; telephone, 209; electro-motograph, 210; at Menlo Park, 210; lighting system, 210-12; dynamo, 211; incandescent lamp, 210-211; experimental electric railway, 214; "Wizard of Menlo Park," 215; at West Orange, 215; storage battery, 216; bibliography, 253
- Edwards, Henrietta, marries Eli Whitney, 183
- Edwards, Jonathan, grandfather of Mrs. Eli Whitney, 183
- Edwards, Judge Pierpont, father of Mrs. Eli Whitney, 183
- Electric lighting, 203, 210-213
- Electric railways, 214
- Electricity, 194 *et seq.*; Franklin's discoveries, 9-11; bibliography, 253-54
- Ellsworth, Annie E., informs Morse of passage of appropriation bill, 142; and first use of telegraph, 143
- Ericsson, John, experiments with steam locomotives, 78, 79; builds *Monitor*, 179
- Erie Canal, Fulton on commission, 68; Stevens addresses commissioners, 75; completed (1825), 77
- Evans, Oliver, 175; application of steam, 23; machine for flour manufacture, 29, 70, 71, 72; invents high-pressure engine, 55-56, 70, 71; quoted, 69-70; early life, 70-71;

- Evans, Oliver—*Continued*
Millwright and Miller's Guide, 71; *Oruktor Amphi-bolos*, 72, 83; *Young Engineer's Guide*, 73; death (1819), 74; prophecy as to use of locomotive, 74; bibliography, 249
- Faraday, Michael, English investigator of electricity, 195; and Henry, 197; dynamo, 202
- Farley, Harriet, in Lowell factory, 93
- Farm inventions, *see* Agricultural machinery
- Farmer, M. G., electric-driven locomotive (1847), 202
- Fessenden, R. A., and wireless telegraphy, 146
- Field, C. W., and Atlantic Cable, 145-46
- Field, S. D., electric railway, 214
- Firearms, Whitney manufactures, 180-82, 183; North's plant, 182; machine tools and standardization of parts, 185; Colt as inventor and manufacturer, 187-91
- Fisher, George, and Howe, 100
- Fitch, John, steamboat, 22-23, 29, 59; patent for distilling alcohol, 30; life, 58-59
- Floridas, Spanish possession (1790), 23
- Folger, Abiah, mother of Franklin, 1
- Folger, Peter, grandfather of Franklin, 1
- France, Franklin in, 19-21; Treaty of Alliance, 21; Fulton in, 63; balloon experiments, 220-24
- Francis, S. W., typewriter, 150
- Franklin, Benjamin, parents, 1; birth (1706), 1; childhood, 2; *Autobiography*, 2; apprenticed, 3; journey to Philadelphia, 3; finds employment, 3; goes to London, 4; *A Dissertation on Liberty and Necessity*, 4; returns to Philadelphia, 4; founds Junto, 5; established in business, 5; *The Nature and Necessity of a Paper Currency*, 5; and *Pennsylvania Gazette*, 6-7, 149; *Poor Richard's Almanack*, 7; keeps a shop, 7; frugality, 8; *Journal of a Voyage from London to Philadelphia*, 8; invents stove, 9; bifocal spectacles, 9; interest in natural phenomena, 8-12; discoveries in electricity, 9-11; elected member of Royal Society, 11; influence, 12-13; establishes first circulating library, 13; founds academy, 13; *Plain Truth*, 13; and American Philosophical Society, 14; Deputy Postmaster General, 14-15; "Albany Plan of Union," 15-16; and Braddock, 16-17; sent to London by Assembly, 18; and the Revolution, 18-21; in Continental Congress, 19; accomplishments (1775-76), 19; envoy to France (1776), 19-21; President of Council of Pennsylvania, 21; Convention of 1787, 21; death (1790), 23; and balloons, 220-25; bibliography, 248
- Franklin, James, brother of Benjamin, 2-3
- Franklin, Josiah, father of Benjamin, 1
- Franklin, William, son of Benjamin, 18
- Franklin Institute, 139
- Franklin stove, 9
- French and Indian Wars, 15-18

- Fulton, Robert, and Henry, 58; as an artist, 61-62; early mechanical ability, 61; in England, 62; invents means of sawing marble, 62-63; improves wheel for spinning flax, 63; machine for making rope, 63; method of raising canal boats, 63; improvement in tanning, 63; *A Treatise on the Improvement of Canal Navigation*, 63; goes to France, 63; interest in submarines, 63-64; interest in steamboat, 64-65; *Clermont*, 60, 65-68; reasons for success, 67; bibliography, 249
- Gale, L. D., colleague of Morse, 138; partnership in telegraph, 139, 142 (note)
- Galvani, Aloisio, Italian investigator of electricity, 195
- Georgia, population (1790), 23; Whitney in, 38 *et seq.*; Whitney's suits, 44-45, 51
- Gifford, George, suggests sewing machine "combination," 105
- Gilbert, William, father of electricity, 194; *On the Magnet*, 195
- Girard, Stephen, Philadelphia merchant, 26
- Glidden, Carlos, suggests typewriter, 151
- Goodwin, Hannibal, cellulose film, 154
- Goodyear, Amasa, father of Charles, 165, 166
- Goodyear, Charles, Goodyear *vs.* Day, 157-60; beginning of interest in rubber, 164-65; birth (1800), 165; early life, 166; imprisonment for debt, 166-67; experiments with rubber, 167-69; discovers process of vulcanization, 169; hardships, 170-72; patent (1844), 172; later life, 174; bibliography, 252
- Goodyear, Stephen, ancestor of Charles, 165
- Goodyear *vs.* Day, 157-60
- Gorham, M. L., invents binder using twine, 119
- Gould, Jay, Edison and, 209
- Gravitation, Newton discovers law of, 12 (note)
- Gray, Stephen, English investigator of electricity, 195
- Great Britain, steam engine, 53-55; monopoly of mechanical contrivances, 65; railway invention in, 77-78, 79; textile industry in, 84-85; Colt in, 191; Edison introduces automatic telegraphy into, 208
- Great War, air craft in, 242
- Great Western*, first transatlantic steamship, 69; Morse on, 139
- Greene, Mrs. Nathanael, and Whitney, 38, 40; marries Miller, 41
- Grieve, attempted transatlantic flight, 243
- Grover and Baker, manufacturers of sewing machines, 106
- Guericke, Otto von, German investigator of electricity, 195
- Gusmao, Bartholomeo de, invents flying machine (1709), 227
- Hackworth, Timothy, maker of locomotive, 79
- Hall, C. M., invents method of aluminum manufacture, 216
- Hammond, "Correspondence of Eli Whitney," cited, 40 (note)
- Hancock, John, Boston merchant, 26

- Hanson, Harriet (Mrs. W. S. Robinson), in Lowell factory, 93
- Hargreaves, James, invents spinning jenny, 35
- Harvesting machinery, 115-123
- Haviland, Geoffrey de, British airplane inventor, 242
- Hawker, attempted transatlantic flight, 243
- Hayrakes, 122
- Hendrick, B. J., *The Age of Big Business*, cited, 117 (note), 146, 209 (note)
- Henry, Joseph, investigator of electricity, 195-96, 200; discoveries, 196-97; principle of electric telegraph, 198-99; at Princeton, 199; Secretary of Smithsonian Institution, 200-01; on Lighthouse Board, 201; and Morse, 201; and Bell, 201-02; blazes way for electric motor, 202; dynamo, 202; bibliography, 253
- Henry, William, constructs steamboat, 58
- Herald*, New York, 146-47
- Herrera, Spanish historian, on rubber balls, 161
- Hewitt, A. S., quoted, 177
- Heyl, Henry, stages first motion pictures, 154-55
- Highland and Agricultural Society of Edinburgh, Bell receives prize from, 116
- Hoe, Robert, printing press, 147, 148
- Hoe, R. M., son of Robert, invents rotary press, 148
- Holmes, Hogden, improves cotton gin, 51
- Hood, Thomas, *The Song of the Shirt*, 98
- Hopkins, Samuel, first to receive patent under Patent Act, 28
- Howe, Elias, birth (1819), 98; early life, 98-99; invents sewing machine, 100-02; in London, 102; poverty, 103; infringements, 103-04; settlement of case favors, 104; combination of inventors and manufacturers, 105-06; bibliography, 250
- Hulbert, A. B., *The Paths of Inland Commerce*, cited, 68 (note)
- Hunt, Walter, invents sewing machine, 100, 104
- Hussey, Obed, patents reaper, 116, 117, 121
- Hydroaeroplane, 241-42
- Iles, George, *Leading American Inventors*, cited, 177 (note)
- Industrial Revolution, 36
- Industry, organization in United States (1790), 25
- Inglis, Charles, and Howe, 103
- Ink, Franklin makes, 4
- Jackson, P. T., brother-in-law of Lowell, 89; mills at Waltham, 90-91
- Jefferson, Thomas, Secretary of State, 39; plough, 112; letter to Jay, cited, 181
- John Bull*, locomotive, 81
- Junto, 5, 9, 14
- Kay, John, invents flying shuttle, 35
- Keimer, Samuel, employs Franklin, 3, 4; bankruptcy, 6
- Keith, Sir William, Governor of Pennsylvania, 4
- Kentucky, pioneers in (1790), 24
- Kertland, Philip, Lynn shoemaker, 108
- Ketchum, W. F., invents mowing machine, 122

- "Kinetoscope," 155
 Knowles, Hazard, invents hinged cutting-bar for mower, 121
- Lana, Francisco, airship, 227
 Lane, John, plough, 113
 Lane, John, son of first, patents steel plough, 113-14
 Langley, S. P., invents air-plane, 229-35
 Langmuir, wireless telegraphy, 146
 Lanston, Tolbert, invents monotype, 149
 Larcom, Lucy, *An Idyl of Work*, 93
 Lathe, Copying, Blanchard invents, 186
 Lathrop, John, Franklin's letter to, 22
 Lawrence, Abbott, and Lowell mills, 93
 Lawrence, Amos, and Lowell mills, 93
 Leonardo da Vinci, artist and inventor, 61; on subject of flight, 226
 Liberty Motors, 242
 Lightning rod, 195
 Lilienthal, Otto, invents glider, 236
 Linotype, 149
 Livingston, R. R., American Minister to France, 64; and Fulton, 64-65; *Clermont* named for estate of, 65-66; Stevens requests influence for railway, 75; statement of objection to railways, 76
 Locomotives, birth of modern, 79; development of, 80-82; *see also* Railroads, Steam engines
 Looms, 36; *see also* Textile industry
 Lowell, F. C., establishes weaving mills, 89, 90; death (1817), 90
- Lowell (Massachusetts), founded, 91-93; Dickens describes, 94-96; changes in, 96-97; bibliography, 250
Lowell Offering, The, 94, 95-96
 Lumière, invents projector for motion pictures, 155
- McCormick, C. H., patents reaper, 116; sale of machines, 117; moves West, 118; business capacity, 118; improvements in reaper, 119
 McKay, Gordon, sole-sewing machine, 108
 McKinley, William, interest in Langley's airplane, 233
 Machine shop, pioneers of, 175 *et seq.*
 Machine tools, *see* Machine shop
 Macintosh, Charles, invents waterproof cloth, 163
 Maine, population (1790), 23
 Manly, C. M., assists Langley, 233-34
 Manning, William, invents reaper, 116, 117
 Marconi, Guglielmo, wireless telegraph, 146
 Menlo Park (New Jersey), Edison's laboratories at, 210; experimental electric railway at, 214
Mercury, rival of *Pennsylvania Gazette*, 6
 Mergenthaler, Ottmar, invents linotype, 149
 Merrimac Manufacturing Company, 91
 Miller, Lewis, mowing machine, 122
 Miller, Phineas, and Whitney, 38, 41, 43, 44, 45, 46; death, 47
 Mohawk and Hudson Railroad, 80
Monitor, ironclad boat, 179

- Monotype, 149
- Montgolfier, invents balloon, 222, 223-24
- Montgomery, James, on Lowell mills, 96
- Moody, Paul, partner in Lowell enterprise, 89, 90, 91
- Moors cultivate cotton, 32
- Moravians, 17
- Morse, Reverend Jedidiah, father of S. F. B., 131, 132
- Morse, Richard, brother of S. F. B., 135
- Morse, Sidney, brother of S. F. B., 135
- Morse, S. F. B., 196; and the telegraph, 129-44; birth (1791), 130; early life, 130-131; interest in electricity, 131, 134; personal characteristics, 132; as a painter, 132-33, 135-36; marriage, 133; poverty, 135, 136-37, 140; at New York University, 137-38; invents telegraph, 138-39; petitions Congress for appropriation, 139, 140, 141-42; goes to Europe, 139-40; and photography, 140, 153; constructs line between Baltimore and Washington, 142; trial message, 143; death (1872), 144; code used in wireless, 146; Henry and, 198, 201; bibliography, 251
- Motion pictures, 154-56; bibliography, 251-52
- Mulliken, Samuel, four patents granted to, 29; invents threshing machine, 120
- "Myrtle, Mina," 93
- New England, post road, 15; textile industry, 84 *et seq.*
- New England Courant*, 3
- New York (State), in 1790, 23
- New York City, Franklin reaches, 3; mail service, 15
- New York University, Morse on teaching staff of, 137
- Newbold, Charles, invents plough, 112
- Newspapers, inventions to facilitate printing, 146-49; bibliography, 251
- North, Simeon, manufactures firearms, 182
- North Carolina, buys patent rights from Whitney, 48
- Northwest Territory, population (1790), 24
- Novelty, The*, locomotive, 79
- Oersted, H. C., Danish investigator of electricity, 195
- Ogle, Henry, invents reaper, 116
- Ohm, G. S., German investigator of electricity, 195
- Oliver, James, Chilled Plow Works, 114
- Olmstead, Denison, *Memoir*, quoted, 183
- Opdyke, George, manufactures clothing, 106-07
- Oruktor Amphibolos*, steam dredging machine, 72, 83
- Otis, E. G., improves elevator, 215
- Page, C. G., drives electric car (1851), 202
- Parlin, William, makes ploughs, 113
- Parsons, C. A., steam turbine, 218
- Patent Act (1790), 27-30; repealed, 30; due to John Stevens, 176; (1793), 30
- Patent Arms Company, 188
- Patent Office, organization, 30
- Paul, invents projector for motion pictures, 155

- Pawtucket Canal Company, 91
 Peacock, David, invents plough, 112
 Pennsylvania in 1790, 23
 "Pennsylvania fireplace," 9
Pennsylvania Gazette, The, 6, 149
 Pennsylvania Society for the Encouragement of Manufactures and Useful Arts, 86
 Pennsylvania, University of, 13
 Philadelphia, Franklin reaches, 3; mail service, 15
Philosophical Magazine, quoted, 197
Phoenix, Stevens's steamboat, 60-61
 Phonograph, 152-53
 Photography, 140, 153-54; bibliography, 251; *see also* Motion pictures
 Pitts, H. A., inventor of horse-power treadmill, 120
 Pitts, J. A., inventor of horse-power treadmill, 120
 Ploughs, 111-15
 Polk, J. K., candidate for Presidency, 144
 Pony Express, 145
 Pope, F. L., partner of Edison, 208
 Pope, Edison, and Company, first firm of electrical engineers in United States, 208
 Potash, first patent for, 28
 Prime, S. I., *The Life of Samuel F. B. Morse*, quoted, 131-132, 138
 Printing, type, 4, 12 (note); punches for type, 29; steam driven press, 147-48; rotary press, 148; stereotyping, 148; photo-engraving, 148; linotype, 149; monotype, 149; bibliography, 251
 Providence (Rhode Island), attempt to make spinning machinery at, 86
 Pullman Cars, 126
 Putnam, Aaron, patent for distilling method, 29
 Radio telegraphy, *see* Wireless telegraphy
 Railroads, Stevens advocates, 75, 77; Livingston's objections to, 76; early, 77-78; beginning of use of locomotive, 79-81; growth, 126; rails invented by Stevens, 178; *see also* Electric railways, Locomotives, Steam engines, Transportation
 Read, Lieutenant-Commander A. C., transatlantic flight, 242-43
 Read, Deborah, wife of Benjamin Franklin, 4, 7-8
 Read, Nathan, 30
 Reapers, 115-20, 121; bibliography, 250
 Remington, Eliphalet, buys typewriter patents, 151-52
 Revolutionary War, Franklin and, 18-21; beginning of, 124
 Richmond (Virginia), first electric railway system, 214
 Robinson, Mrs. W. S., in Lowell mills, 93
Rocket, The, locomotive, 79
 Roe, J. W. *English and American Tool Builders*, cited, 45 (note), 49 (note), 181 (note), 185 (note); quoted, 182
 Root, E. K., and Colt factory, 190
 Roxbury (Massachusetts), attempt to make waterproof clothing at, 163-64
 Royal Society, Franklin elected member of, 11
Royal William, steamship, 69
 Rozier, Pilâtre de, first balloon flight, 221

- Rubber, 157 *et seq.*; bibliography, 252
- Rumsey, James, steamboat, 23, 29, 58
- Rust, Samuel, Washington press, 147
- Ryneveld, Captain van, flight, from Cairo to the Cape, 244
- Saint, Thomas, patents sewing machine, 99
- Sampson, J. S., patent for method of making candles, 29
- Sanspareil, The*, locomotive, 79
- Saturday Evening Post, The*, 6
- Saunders, Richard, alleged publisher of *Poor Richard's Almanack*, 7
- Savannah (Georgia), post road to, 15
- Savannah*, sailing packet using steam, 69
- Scott, Major G. H., in British dirigible, Scotland to New York, 244
- Sellers, Coleman, *Oliver Evans and his Inventions*, cited, 70 (note)
- Sewing machine, 98 *et seq.*
- Shirley, Governor of Massachusetts, problem of raising funds for defense, 16
- Shoe industry, 107-09
- Sholes, C. L., invents typewriter, 151
- Shuttle, flying, 35
- Silliman, Benjamin, Morse a student under, 130
- Singer, I. M., and sewing machine, 104, 105, 106
- Slater, Samuel, comes to United States, 86; introduces spinning machinery, 87-88, 97
- Slavery, effect of cotton gin on, 49-50; and Civil War, 124
- Smith, F. O. J., partner of Morse, 142 (note)
- Smith, Captain Sir Ross, flight from England to Australia, 244
- Smithson, James, bequest to United States, 200
- Smithsonian Institution, Henry as head of, 200-01
- Soule, S. W., and the typewriter, 151
- South, Whitney in, 37 *et seq.*; effect of cotton gin on, 124, 125
- South Carolina, pays Whitney for patent rights, 45-46; suspends contract with Whitney, 47-48
- Spectator*, London, quoted in *Pennsylvania Gazette*, 6
- Spinning jenny, 35
- Spinning machinery, *see* Textile industry
- Sprague, F. J., designs motors, 213; electric railway, 214
- Stanhope, Earl, Fulton and, 62
- Steam, Greeks discover applicability of, 12 (note)
- Steam engines, 53 *et seq.*; *see also* Locomotives
- Steam turbine, 83
- Stebbins, Josiah, Whitney's letter to, 44, 47-48
- Stephenson, George, experiments with steam, 78; *The Rocket*, 79; builds *John Bull*, 81
- Stephenson, Robert, *The Rocket*, 79
- Stevens, E. A., youngest son of John, 177; founds Stevens Institute of Technology, 178; inventions, 178
- Stevens, John, sets up machine shop, 23; patent for propelling boat, 29; attacks steamboat problem, 59-60; *Phoenix*, 60-61; communication

- Stevens, John—*Continued*
to Erie Canal commissioners,
75, 77; Livingston's answer
to, 76; experiments with
locomotive, 78; interest in
railroad, 75, 77, 78, 175;
father of American patent
law, 176; property on Hud-
son, 176-77; death (1838),
177; bibliography, 249, 252
- Stevens, J. A., son of John, 177
- Stevens, J. C., son of John, 177
- Stevens, R. L., son of John,
177; mechanical star of
family, 178; first ironclad
battleship, 179
- Stevens Battery, first ironclad
battleship, 179
- Stevens family, bibliography,
252
- Stevens Institute of Technol-
ogy, 178
- Stone, John, patent for method
of driving piles, 29
- Stourbridge Lion*, locomotive,
78-79
- Strother, General, story of
Morse, 136-37
- Strutt, Jedediah, partner of
Arkwright, 86
- Sturgeon, William, on Henry,
197
- Submarines, Fulton's interest
in, 63-64; invented by Bush-
nell, 64 (note)
- Sully, ship, 134
- Sun, New York, 147
- Sutcliffe, A. C., *Robert Fulton
and the Clermont*, cited, 65
(note)
- Swan, English inventor of
carbon filament, 211
- Tack-making machine, 186
- Tariff, beginning of protective,
90
- Taylor, Zachary, Colt supplies
revolvers to, 189
- Tedders, 122
- Telegraph, 128 *et seq.*; bibli-
ography, 251
- Telephone, 146; bibliography,
251
- Telluride (Colorado), hydro-
station at, 218-19
- Tennessee, pioneers in (1790),
24; buys Whitney's patents,
48
- Tesla, Nicola, inventor using
alternating current, 218
- Textile industry, in England,
33; British inventions, 35-
36, 125; in New England, 84
et seq., 125; *see also* Cotton
manufacture
- Thimmonier, French inventor
of sewing machine, 99-100
- Thomas, buys English rights
in sewing machine, 102
- Thomson, Elihu, process of
welding, 216; chief American
inventor in domain of alter-
nating current, 217-18
- Threshing machines, 120-21
- Thurber, Charles, invents
typewriter, 150
- Times*, London, uses American
machines, 148
- Tom Thumb*, locomotive, 80
- Tompkins, D. A., *Cotton and
Cotton Oil*, quoted, 42
- Transportation, in 1790, 26;
need for better, 57; *see also*
Railroads
- Trevithick, Richard, 78; in-
vents high-pressure engine,
55; and Evans, 56
- Tribune*, New York, 147
- Trolley system, *see* Electric
railways
- Turner, C. C., *The Romance of
Aeronautics*, quoted, 236-37
- Type, *see* Printing
- Typewriters, 149-52; bibli-
ography, 251
- "Unitas Fratrum," 17
- United States, population

- United States—*Continued*
 (1790), 23-24; industries, 24-25; mineral resources, 25; cotton production, 49; population (1860), 124
Universal Instructor in All Arts and Sciences and Pennsylvania Gazette, The, 6
- Vail, Alfred, Morse and, 138, 139, 142 (note)
- Vail, Judge Stephen, advances money for Morse's experiments, 138
- Van Depoele, C. J., contributions to electric railway, 214
- Vanderbilt, Cornelius, Good-year and, 170
- Voight, Harry, associate of Fitch, 59
- Volta, Alessandro, Italian investigator of electricity, 195
- Wages, 125-26
- Walker, Lucretia, wife of S. F. B. Morse, 133
- Waltham, textile mill at, 89
- War of 1812, delays establishment of railroads, 77
- Washington, George, and Eli Whitney, 184
- Watt, James, steam engine, 22, 36, 53-55, 56, 184; bibliography, 249
- Webster, Daniel, Goodyear *vs.* Day, 157-60; quoted, 164
- West, Benjamin, and Fulton, 62; Morse studies under, 133
- West Point*, locomotive, 81
- Western Union Telegraph Company, 209
- Westinghouse, George, automatic air brake, 126; inventor, 218
- Wheeler and Wilson, manufacturers of sewing machines, 106
- Whitney, Eli, and the cotton gin, 32 *et seq.*; birth (1765), 36; youth, 36-37; education, 37; letter to his father quoted, 38-40; plan for commercializing invention, 41-43; infringements on patent 44, 45; States buy patent rights, 45-48; fight for rights in Georgia, 51; manufacture of firearms, 52, 180-82, 183; standardization of parts, 180-82; marriage, 183; death (1825), 184; business sold to Winchester Repeating Arms Company, 184; bibliography, 248-49, 252-53
- Wilkinson, John, English machine tool inventor, 184
- Wilson, A. B., inventions on sewing machine, 104
- Wilson, T. L., produces calcium carbide, 217
- Winchester Repeating Arms Company buys Whitney's business, 184
- "Wizard of Menlo Park," name for Edison, 215
- Wood, Jethro, invents plough, 112
- Wright, Orville, and the airplane, 235-40
- Wright, Silas, telegraph brings refusal of nomination to convention, 144
- Wright, Wilbur, and the airplane, 235-40

PART II

THE AGE OF BIG BUSINESS

A CHRONICLE
OF THE CAPTAINS OF INDUSTRY
BY
BURTON J. HENDRICK

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CONTENTS

✓ I.	INDUSTRIAL AMERICA AT THE END OF THE CIVIL WAR	Page	1
✓ II.	THE FIRST GREAT AMERICAN TRUST	"	25
✓ III.	THE EPIC OF STEEL	"	58
✓ IV.	THE TELEPHONE: AMERICA'S MOST POET- ICAL ACHIEVEMENT	"	86
V.	THE DEVELOPMENT OF PUBLIC UTIL- ITIES	"	119
VI.	MAKING THE WORLD'S AGRICULTURAL MACHINERY	"	149
VII.	THE DEMOCRATIZATION OF THE AUTO- MOBILE	"	170
	BIBLIOGRAPHICAL NOTE	"	189
	INDEX	"	191



THE AGE OF BIG BUSINESS

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CHAPTER I

INDUSTRIAL AMERICA AT THE END OF THE CIVIL WAR

A COMPREHENSIVE survey of the United States, at the end of the Civil War, would reveal a state of society which bears little resemblance to that of today. Almost all those commonplace fundamentals of existence, the things that contribute to our bodily comfort while they vex us with economic and political problems, had not yet made their appearance. The America of Civil War days was a country without transcontinental railroads, without telephones, without European cables, or wireless stations, or automobiles, or electric lights, or sky-scrapers, or million-dollar hotels, or trolley cars, or a thousand other contrivances that today supply the conveniences and comforts of what we call our American civilization. The cities of that

period, with their unsewered and unpaved streets, their dingy, flickering gaslights, their ambling horse-cars, and their hideous slums, seemed appropriate settings for the unformed social life and the rough-and-ready political methods of American democracy. The railroads, with their fragile iron rails, their little wheezy locomotives, their wooden bridges, their unheated coaches, and their kerosene lamps, fairly typified the prevailing frontier business and economic organization. But only by talking with the business leaders of that time could we have understood the changes that have taken place in fifty years. For the most part we speak a business language which our fathers and grandfathers would not have comprehended. The word "trust" had not become a part of their vocabulary; "restraint of trade" was a phrase which only the antiquarian lawyer could have interpreted; "interlocking directorates," "holding companies," "subsidiaries," "underwriting syndicates," and "community of interest" — all this jargon of modern business would have signified nothing to our immediate ancestors. Our nation of 1865 was a nation of farmers, city artisans, and industrious, independent business men, and small-scale manufacturers. Millionaires, though they were not

unknown, did not swarm all over the land. Luxury, though it had made great progress in the latter years of the war, had not become the American standard of well-being. The industrial story of the United States in the last fifty years is the story of the most amazing economic transformation that the world has ever known; a change which is fitly typified in the evolution of the independent oil-driller of western Pennsylvania into the Standard Oil Company, and of the ancient open air forge on the banks of the Allegheny into the United States Steel Corporation.

The slow, unceasing ages had been accumulating a priceless inheritance for the American people. Nearly all of their natural resources, in 1865, were still lying fallow, and even undiscovered in many instances. Americans had begun, it is true, to exploit their more obvious, external wealth, their forests and their land; the first had made them one of the world's two greatest shipbuilding nations, while the second had furnished a large part of the resources that had enabled the Federal Government to fight what was, up to that time, the greatest war in history. But the extensive prairie plains whose settlement was to follow the railroad extensions of the sixties and the seventies — Kansas,

Nebraska, Iowa, Oklahoma, Minnesota, the Dakotas — had been only slightly penetrated. This region, with a rainfall not too abundant and not too scanty, with a cultivable soil extending from eight inches to twenty feet under the ground, with hardly a rock in its whole extent, with scarcely a tree, except where it bordered on the streams, has been pronounced by competent scientists the finest farming country to which man has ever set the plow. Our mineral wealth was likewise lying everywhere ready to the uses of the new generation. The United States now supplies the world with half its copper, but in 1865 it was importing a considerable part of its own supply. It was not till 1859 that the first "oil gusher" of western Pennsylvania opened up an entirely new source of wealth. Though we had the largest coal deposits known to geologists, we were bringing large supplies of this indispensable necessity from Nova Scotia. It has been said that coal and iron are the two mineral products that have chiefly affected modern civilization. Certainly the nations that have made the greatest progress industrially and commercially — England, Germany, America — are the three that possess these minerals in largest amount. From sixty to seventy per cent of all the known

coal deposits in the world were located in our national domain. Nature had given no other nation anything even remotely comparable to the four hundred and eighty square miles of anthracite in western Pennsylvania and West Virginia. Enormous fields of bituminous lay in those Appalachian ranges extending from Pennsylvania to Alabama, in Michigan, in the Rocky Mountains, and in the Pacific regions. In speaking of our iron it is necessary to use terms that are even more extravagant. From colonial times Americans had worked the iron ore plentifully scattered along the Atlantic coast, but the greatest field of all, that in Minnesota, had not been scratched. From the settlement of the country up to 1869 it had mined only 50,000,000 tons of iron ore; while up to 1910 we had produced 685,000,000 tons. The streams and waterfalls that, in the next sixty years, were to furnish the power that would light our cities, propel our street-cars, drive our transcontinental trains across the mountains, and perform numerous domestic services, were running their useless courses to the sea.

Industrial America is a product of the decades succeeding the Civil War; yet even in 1865 we were a large manufacturing nation. The leading

characteristic of our industries, as compared with present conditions, was that they were individualized. Nearly all had outgrown the household stage, the factory system had gained a foothold in nearly every line, even the corporation had made its appearance, yet small-scale production prevailed in practically every field. In the decade preceding the War, vans were still making regular trips through New England and the Middle States, leaving at farmhouses bundles of straw plait, which the members of the household fashioned into hats. The farmers' wives and daughters still supplemented the family income by working on goods for city dealers in ready-made clothing. We can still see in Massachusetts rural towns the little shoe shops in which the predecessors of the existing factory workers soled and heeled the shoes which shod our armies in the early days of the Civil War. Every city and town had its own slaughter house; New York had more than two hundred; what is now Fifth Avenue was frequently encumbered by large droves of cattle, and great stockyards occupied territory which is now used for beautiful clubs, railroad stations, hotels, and the highest class of retail establishments.

In this period before the Civil War compara-

tively small single owners, or frequently copartnerships, controlled practically every industrial field. Individual proprietors, not uncommonly powerful families which were almost feudal in character, owned the great cotton and woolen mills of New England. Separate proprietors, likewise, controlled the iron and steel factories of New York State and Pennsylvania. Indeed it was not until the War that corporations entered the iron industry, now regarded as the field above all others adapted to this kind of organization. The manufacture of sewing machines, firearms, and agricultural implements started on a great scale in the Civil War; still, the prevailing unit was the private owner or the partnership. In many manufacturing lines the joint stock company had become the prevailing organization, but even in these fields the element that so characterizes our own age, that of combination, was exerting practically no influence.

Competition was the order of the day: the industrial warfare of the sixties was a free-for-all. A mere reference to the status of manufactures in which the trust is now the all-prevailing fact will make the contrast clear. In 1865 thousands of independent companies were drilling oil in Pennsylvania and there were more than two hundred which

✓ were refining the product. Nearly four hundred and fifty operators were mining coal, not even dimly foreseeing the day when their business would become a great railroad monopoly. The two hundred companies that were making mowers and reapers, seventy-five of them located in New York State, had formed no mental picture of the future International Harvester Company. One of our first large industrial combinations was that which in the early seventies absorbed the manufacturers of salt; yet the close of the Civil War found fifty competing companies making salt in the Saginaw Valley of Michigan. In the same State, about fifty distinct ownerships controlled the copper mines, while in Nevada the Comstock Lode had more than one hundred proprietors. The modern trust movement has now absorbed even our lumber and mineral lands, but in 1865 these rich resources were parceled out among a multiplicity of owners. No business has offered greater opportunities to the modern promoter of combinations than our street railways. In 1865 most of our large cities had their leisurely horse-car systems, yet practically every avenue had its independent line. New York had thirty separate companies engaged in the business of local transportation. Indeed the Civil War

period developed only one corporation that could be described as a "trust" in the modern sense. This was the Western Union Telegraph Company. Incredible as it may seem, more than fifty companies, ten years before the Civil War, were engaged in the business of transmitting telegraphic messages. These companies had built their telegraph lines precisely as the railroads had laid their tracks; that is, independent lines were constructed connecting two given points. It was inevitable, of course, that all these scattered lines should come under a single control, for the public convenience could not be served otherwise. This combination was effected a few years before the War, when the Western Union Telegraph Company, after a long and fierce contest, succeeded in absorbing all its competitors. Similar forces were bringing together certain continuous lines of railways, but the creation of huge trunk systems had not yet taken place. How far our industrial era is removed from that of fifty years ago is apparent when we recall that the proposed capitalization of \$15,000,000, caused by the merging of the Boston and Worcester and the Western railroads, was widely denounced as "monstrous" and as a corrupting force that would destroy our Republican institutions.

Naturally this small-scale ownership was reflected in the distribution of wealth. The "swollen fortunes" of that period rested upon the same foundation that had given stability for centuries to the aristocracies of Europe. Social preëminence in large cities rested almost entirely upon the ownership of land. The Astors, the Goelets, the Rhinelanders, the Beekmans, the Brevoorts, and practically all the mighty families that ruled the old Knickerbocker aristocracy in New York were huge landed proprietors. Their fortunes thus had precisely the same foundation as that of the Prussian Junkers today. But their accumulations compared only faintly with the fortunes that are commonplace now. How many "millionaires" there were fifty years ago we do not precisely know. The only definite information we have is a pamphlet published in 1855 by Moses Yale Beach, proprietor of the *New York Sun*, on the "Wealthy Men of New York." This records the names of nineteen citizens who, in the estimation of well-qualified judges, possessed more than a million dollars each. The richest man in the list was William B. Astor, whose estate is estimated at \$6,000-000. The next richest man was Stephen Whitney, also a large landowner, whose fortune is listed at

\$5,000,000. Then comes James Lenox, again a landed proprietor, with \$3,000,000. The man who was to accumulate the first monstrous American fortune, Cornelius Vanderbilt, is accredited with a paltry \$1,500,000. Mr. Beach's little pamphlet sheds the utmost light upon the economic era preceding the Civil War. It really pictures an industrial organization that belongs as much to ancient history as the empire of the Cæsars. His study lists about one thousand of New York's "wealthy citizens." Yet the fact that a man qualified for entrance into this Valhalla who had \$100,000 to his credit and that nine-tenths of those so chosen possessed only that amount shows the progress concentrated riches have made in sixty years. How many New Yorkers of today would look upon a man with \$100,000 as "wealthy"?

The sources of these fortunes also show the economic changes our country has undergone. To-day, when we think of our much exploited millionaires, the phrase "captains of industry" is the accepted description; in Mr. Beach's time the popular designation was "merchant prince." His catalogue contains no "oil magnates" or "steel kings" or "railroad manipulators"; nearly all the industrial giants of ante-bellum times — as

distinguished from the socially prominent whose wealth was inherited — had heaped together their accumulations in humdrum trade. Perhaps Peter Cooper, who had made a million dollars in the manufacture of isinglass and glue, and George Law, whose gains, equally large, represented fortunate speculations in street railroads, faintly suggest the approaching era; yet the fortunes which are really typical are those of William Aspinwall, who made \$4,000,000 in the shipping business, of A. T. Stewart, whose \$2,000,000 represented his earnings as a retail and wholesale dry goods merchant, and of Peter Harmony, whose \$1,000,000 had been derived from happy trade ventures in Cuba and Spain. Many of the reservoirs of this ante-bellum wealth sound strangely in our modern ears. John Haggerty had made \$1,000,000 as an auctioneer; William L. Coggeswell had made half as much as a wine importer; Japhet Bishop had rounded out an honest \$600,000 from the profits of a hardware store; while Phineas T. Barnum ranks high in the list by virtue of \$800,000 accumulated in a business which it is hardly necessary to specify. Indeed his name and that of the great landlords are almost the only ones in this list that have descended to posterity. Yet they were the

Rockefellers, the Carnegies, the Harrimans, the Fricks, and the Henry Fords of their day.

Before the Civil War had ended, however, the transformation of the United States from a nation of farmers and small-scale manufacturers to a highly organized industrial state had begun. Probably the most important single influence was the War itself. Those four years of bitter conflict illustrate, perhaps more graphically than any similar event in history, the power which military operations may exercise in stimulating all the productive forces of a people. In thickly settled nations, with few dormant resources and with practically no areas of unoccupied land, a long war usually produces industrial disorganization and financial exhaustion. The Napoleonic wars had this effect in Europe; in particular they caused a period of social and industrial distress in England. The few years immediately following Waterloo marked a period when starving mobs rioted in the streets of London, setting fire to the houses of the aristocracy and stoning the Prince Regent whenever he dared to show his head in public, when cotton spindles ceased to turn, when collieries closed down, when jails and workhouses were overflowing with a wretched proletariat, and when gaunt and

homeless women and children crowded the country highways. No such disorders followed the Civil War in this country, at least in the North and West. Spiritually the struggle accomplished much in awakening the nation to a consciousness of its great opportunities. The fact that we could spend more than a million dollars a day — expenditures that hardly seem startling in amount now, but which were almost unprecedented then — and that soon after hostilities ceased we rapidly paid off our large debt, directed the attention of foreign capitalists to our resources, and gave them the utmost confidence in this new investment field. Immigration, too, started after the war at a rate hitherto without parallel in our annals. The Germans who had come in the years preceding the Civil War had been largely political refugees and democratic idealists, but now, in much larger numbers, began the influx of north and south Germans whose dominating motive was economic. These Germans began to find their way to the farms of the Mississippi Valley; the Irish began once more to crowd our cities; the Slavs gravitated towards the mines of Pennsylvania; the Scandinavians settled whole counties of certain northwestern States; while the Jews began that conquest of the tailoring

industries that was ultimately to make them the clothiers of a hundred million people. For this industrial development, America supplied the land, the resources, and the business leaders, while Europe furnished the liquid capital and the laborers.

Even more directly did the War stimulate our industrial development. Perhaps the greatest effect was the way in which it changed our transportation system. The mere necessity of constantly transporting hundreds of thousands of troops and war supplies demanded reconstruction and reëquipment on an extensive scale. The American Civil War was the first great conflict in which railroads played a conspicuous military part, and their development during those four years naturally left them in a strong position to meet the new necessities of peace. One of the first effects of the War was to close the Mississippi River; consequently the products of the Western farms had to go east by railroad, and this fact led to that preëminence of the great trunk lines which they retain to this day. Almost overnight Chicago became the great Western shipping center, and though the river boats lingered for a time on the Ohio and the Mississippi they grew fewer year

by year. Prosperity, greater than the country had ever known, prevailed everywhere in the North throughout the last two years of the War.

So, too, feeding and supplying an army of millions of men laid the foundation of many of our greatest industries. The Northern soldiers in the early days of the war were clothed in garments so variegated that they sometimes had trouble in telling friend from foe, and not infrequently they shot at one another; so inadequately were our woolen mills prepared to supply their uniforms! But larger government contracts enabled the proprietors to reconstruct their mills, install modern machines, and build up an organization and a prosperous business that still endures. Making boots and shoes for Northern soldiers laid the foundation of America's great shoe industry. Machinery had already been applied to shoe manufacture, but only to a limited extent; under the pressure of war conditions, however, American inventive skill found ways of performing mechanically almost all the operations that had formerly been done by hand. The McKay sewing machine, one of the greatest of our inventions, which was perfected in the second year of the war, did as much perhaps as any single device to keep our soldiers

well shod and comfortable. The necessity of feeding these same armies created our great packing plants. Though McCormick had invented his reaper several years before the war, the new agricultural machinery had made no great headway. Without this machinery, however, our Western farmers could never have harvested the gigantic crops which not only fed our soldiers but laid the basis of our economic prosperity. Thus the War directly established one of the greatest, and certainly one of the most romantic, of our industries — that of agricultural machinery.

Above all, however, the victory at Appomattox threw upon the country more than a million unemployed men. Our European critics predicted that their return to civil life would produce dire social and political consequences. But these critics were thinking in terms of their own countries; they failed to consider that the United States had an immense unoccupied domain which was waiting for development. The men who fought the Civil War had demonstrated precisely the adventurous, hardy instincts which were most needed in this great enterprise. Even before the War ended, a great immigration started towards the mines and farms of the trans-Mississippi

country. There was probably no important town or district west of the Alleghanies that did not absorb a considerable number. In most instances, too, our ex-soldiers became leaders in these new communities. Perhaps this movement has its most typical and picturesque illustration in the extent to which the Northern soldiers opened up the oil-producing regions of western Pennsylvania. Venango County, where this great development started, boasted that it had more ex-soldiers than any similar section of the United States.

The Civil War period also forced into prominence a few men whose methods and whose achievements indicated, even though roughly and indistinctly, a new type of industrial leadership. Every period has its outstanding figure and, when the Civil War was approaching its end, one personality had emerged from the humdrum characters of the time — one man who, in energy, imagination, and genius, displayed the forces that were to create a new American world. Although this man employed his great talents in a field, that of railroad transportation, which lies outside the scope of the present volume, yet in this comprehensive view I may take Cornelius Vanderbilt as the symbol that links the old industrial era with the new. He is worthy of

more detailed study than he has ever received, for in personality and accomplishments Vanderbilt is the most romantic figure in the history of American finance. We must remember that Vanderbilt was born in 1794 and that at the time we are considering he was seventy-one years old. In the matter of years, therefore, his career apparently belongs to the ante-bellum days, yet the most remarkable fact about this remarkable man is that his real life work did not begin until he had passed his seventieth year. In 1865 Vanderbilt's fortune, consisting chiefly of a fleet of steamboats, amounted to about \$10,000,000; he died twelve years later, in 1877, leaving \$104,000,000, the first of those colossal American fortunes that were destined to astound the world. The mere fact that this fortune was the accumulated profit of only ten years shows perhaps more eloquently than any other circumstance that the United States had entered a new economic age. That new factor in the life of America and the world, the railroad, explains his achievement. Vanderbilt was one of the most astonishing characters in our history. His physical exterior made him perhaps the most imposing figure in New York. In his old age, at seventy-three, Vanderbilt married his second wife, a beautiful

Southern widow who had just turned her thirtieth year, and the appearance of the two, sitting side by side in one of the Commodore's smartest turnouts, driving recklessly behind a pair of the fastest trotters of the day, was a common sight in Central Park. Nor did Vanderbilt look incongruous in this brilliant setting. His tall and powerful frame was still erect, and his large, defiant head, ruddy cheeks, sparkling, deep-set black eyes, and snowy white hair and whiskers, made him look every inch the Commodore. These public appearances lent a pleasanter and more sentimental aspect to Vanderbilt's life than his intimates always perceived. For his manners were harsh and uncouth; he was totally without education and could write hardly half a dozen lines without outraging the spelling-book. Though he loved his race-horses, had a fondness for music, and could sit through long winter evenings while his young wife sang old Southern ballads, Vanderbilt's ungovernable temper had placed him on bad terms with nearly all his children — he had had thirteen, of whom eleven survived him — who contested his will and exposed all his eccentricities to public view on the ground that the man who created the New York Central system was actually insane. Vanderbilt's methods and his tem-

perament presented such a contrast to the commonplace minds which had previously dominated American business that this explanation of his career is perhaps not surprising. He saw things in their largest aspects and in his big transactions he seemed to act almost on impulse and intuition. He could never explain the mental processes by which he arrived at important decisions, though these decisions themselves were invariably sound. He seems to have had, as he himself frequently said, almost a seer-like faculty. He saw visions, and he believed in dreams and in signs. The greatest practical genius of his time was a frequent attendant at spiritualistic seances; he cultivated personally the society of mediums, and in sickness he usually resorted to mental healers, mesmerists, and clairvoyants. Before making investments or embarking in his great railroad ventures, Vanderbilt visited spiritualists; we have one circumstantial account of his summoning the wraith of Jim Fiske to advise him in stock operations. His excessive vanity led him to print his picture on all the Lake Shore bonds; he proposed to New York City the construction in Central Park of a large monument that would commemorate, side by side, the names of Vanderbilt and Washington; and he actually



erected a large statue to himself in his new Hudson River station in St. John's Park. His attitude towards the public was shown in his remark when one of his associates told him that "each and every one" of certain transactions which he had just forced through "is absolutely forbidden by the statutes of the State of New York." "My God, John!" said the Commodore, "you don't suppose you can run a railroad in accordance with the statutes of the State of New York, do you?" "Law!" he once roared on a similar occasion, "What do I care about law? Hain't I got the power?"

These things of course were the excrescences of an extremely vital, overflowing, imaginative, energetic human being; they are traits that not infrequently accompany genius. And the work which Vanderbilt did remains an essential part of our economic organization today. Before his time a trip to Chicago meant that the passenger changed trains seventeen times, and that all freight had to be unloaded at a similar number of places, carted across towns, and reloaded into other trains. The magnificent railroad highway that extends up the banks of the Hudson, through the Mohawk Valley, and alongside the borders of Lake Erie — a water line route nearly the entire distance — was all but

useless. It is true that not all the consolidation of these lines was Vanderbilt's work. In 1853 certain millionaires and politicians had linked together the several separate lines extending from Albany to Buffalo, but they had managed the new road so wretchedly that the largest stockholders in 1867 begged Vanderbilt to take over the control. By 1873 the Commodore had acquired the Hudson River, extending from New York to Albany, the New York Central extending from Albany to Buffalo, and the Lake Shore which ran from Buffalo to Chicago. In a few years these roads had been consolidated into a smoothly operating system. If, in transforming these discordant railroads into one, Vanderbilt bribed legislatures and corrupted courts, if he engaged in the largest stock-watering operations on record up to that time, and took advantage of inside information to make huge winnings on the stock exchange, he also ripped up the old iron rails and relaid them with steel, put down four tracks where formerly there had been two, replaced wooden bridges with steel, discarded the old locomotives for new and more powerful ones, built splendid new terminals, introduced economies in a hundred directions, cut down the hours required in a New York-Chicago trip from fifty to twenty-four, made

his highway an expeditious line for transporting freight, and transformed railroads that had formerly been the playthings of Wall Street and that frequently could not meet their pay-rolls into exceedingly profitable, high dividend paying properties. In this operation Vanderbilt typified the era that was dawning — an era of ruthlessness, of personal selfishness, of corruption, of disregard of private rights, of contempt for law and legislatures, and yet of vast and beneficial achievement. The men of this time may have traveled roughshod to their goal, but after all, they opened up, in an amazingly short time, a mighty continent to the uses of mankind. The triumph of the New York Central and Hudson River Railroad under Vanderbilt, a triumph which dazzled European investors as well as our own, and which represented an entirely different business organization from anything the nation had hitherto seen, appropriately ushered in the new business era whose outlines will be sketched in the succeeding pages.

CHAPTER II

THE FIRST GREAT AMERICAN TRUST

WHEN Cornelius Vanderbilt died in 1877, America's first great industrial combination had become an established fact. In that year the Standard Oil Company of Ohio controlled at least ninety per cent of the business of refining and marketing petroleum. A new portent had appeared in our economic life, a phenomenon that was destined to affect not only the social and business existence of the every-day American but even his political and legal institutions.

It seems natural enough at the present time to refer to petroleum as an indispensable commodity. At the beginning of the Civil War, however, any such description would have been absurd. Though petroleum was not unknown, millions of American households were still burning candles, whale oil, and other illuminants. Not until 1859 did our ancestors realize that, concealed in the rocks of

western Pennsylvania, lay apparently inexhaustible quantities of a liquid which, when refined, would give a light exceeding in brilliancy anything they had hitherto known. The mere existence of petroleum, it is true, had been a familiar fact for centuries. Herodotus mentions the oil pits of Babylon, and Pliny informs us that this oil was actually used for lighting in certain parts of Sicily. It had never become an object of universal use, simply because no one had discovered how to obtain it in sufficient quantities. No one had suspected, indeed, that petroleum existed practically in the form of great subterranean rivers, lakes, or even seas. For ages this great natural treasure had been seeking to advertise its presence by occasionally seeping through the rocks and appearing on the surface of watercourses. It had been doing this all over the world — in China, in Russia, in Germany, in England, in our own country. Yet our obtuse ancestors had for centuries refused to take the hint. We can find much cause for self-congratulation in that it was apparently the American mind that first acted upon this obvious suggestion.

In Venango County, Pennsylvania, petroleum floated in such quantities on the surface of a branch of the Allegheny River that this small watercourse

had for generations been known as Oil Creek. The neighboring farmers used to collect the oil and use it to grease their wagon axles; others, more enterprising, made a business of gathering the floating substance, packing it in bottles, and selling it broadcast as a medicine. The most famous of these concoctions, "Seneca Oil," was widely advertised as a sure cure for rheumatism, and had an extensive sale in this country. "Kier's Rock Oil" afterwards had an even more extended use. Samuel M. Kier, who exploited this comprehensive cure-all, made no lasting contributions to medical science, but his method of obtaining his medicament led indirectly to the establishment of a great industry. In this western Pennsylvania region salt manufacture had been a thriving business for many years; the salt was obtained from salt water by means of artesian wells. This salt water usually came to the surface contaminated with that same evil-smelling oil which floated so constantly on top of the rivers and brooks. The salt makers spent much time and money "purifying" their water from this substance, never apparently suspecting that the really valuable product of their wells was not the salt water they so carefully preserved, but the petroleum which they threw away. Samuel M. Kier was

originally a salt manufacturer; more canny than his competitors, he sold the oil which came up with his water as a patent medicine. In order to give a mysterious virtue to this remedy, Kier printed on his labels the information that it had been "pumped up with salt water about four hundred feet below the earth's surface." His labels also contained the convincing picture of an artesian well — a rough woodcut which really laid the foundation of the Standard Oil Company.

✓ In the late fifties Mr. George H. Bissell had become interested in rock oil, not as an embrocation and as a cure for most human ills, but as a light-giving material. A professor at Dartmouth had performed certain experiments with this substance which had sunk deeply into Bissell's imagination. So convinced was this young man that he could introduce petroleum commercially that he leased certain fields in western Pennsylvania and sent a specimen of the oil to Benjamin Silliman, Jr., Professor of Chemistry at Yale. Professor Silliman gave the product a more complete analysis than it had ever previously received and submitted a report which is still the great classic in the scientific literature of petroleum. This report informed Bissell that the substance could be refined cheaply and

easily, and that, when refined, it made a splendid illuminant, besides yielding certain by-products, such as paraffin and naphtha, which had a great commercial value. So far, Bissell's enterprise seemed to promise success, yet the great problem still remained: how could he obtain this rock oil in amounts large enough to make his enterprise a practical one? A chance glimpse of Kier's label, with its picture of an artesian well, supplied Bissell with his answer. He at once sent E. L. Drake into the oil-fields with a complete drilling equipment, to look, not for salt water, but for oil. Nothing seems quite so obvious today as drilling a well into the rock to discover oil, yet so strange was the idea in Drake's time that the people of Titusville, where he started work, regarded him as a lunatic and manifested a hostility to his enterprise that delayed operations for several months. Yet one day in August, 1859, the coveted liquid began flowing from "Drake's folly" at the rate of twenty-five barrels a day.

Because of this performance Drake has gone down to fame as the man who "discovered oil." In the sense that his operation made petroleum available to the uses of mankind, Drake was its discoverer, and his achievement seems really a

greater one than that of the men who first made apparent our beds of coal, iron, copper, or even gold. For Drake really uncovered an entirely new substance. And the country responded spontaneously to Drake's success. For anything approaching the sudden rush to the oil-fields we shall have to go to the discovery of gold in California ten years before. Men flocked into western Pennsylvania by the thousands; fortunes were made and lost almost instantaneously. Oil flowed so plentifully in this region that it frequently ran upon the ground, and the "gusher," which threw a stream of the precious liquid sometimes a hundred feet and more into the air, became an almost every-day occurrence. The discovery took the whole section by surprise; there were no towns, no railways, and no wagon roads except a few almost impassable lumber trails. Yet, almost in a twinkling, the whole situation changed; towns sprang up overnight, roads were built, over which teamsters could carry the oil to the nearest shipping points, and the great trunk lines began to extend branches into the regions. The one thing, next to Drake's well, that made the oil available, was the discovery, which was made by Samuel Van Syckel, that a two-inch pipe, starting at the well, could convey the oil for

several miles to the nearest railway station. In a few years the whole oil region of Venango County was an inextricable tangle of these primitive pipe lines.

Thus, before the Civil War had ended, the western Pennsylvania wilderness had been transformed into the busy headquarters of a new industry. Companies had been formed, many of them the wildest stock-jobbing operations, refineries had been started, in a few years the whalers of New England had almost lost their occupation, but millions of American homes, that had hitherto had to spend the long winter evenings almost in darkness, suddenly found themselves flooded with light. In Cleveland, in Pittsburgh, in Philadelphia, in New York, and in the oil regions, the business of refining and selling petroleum had reached extensive proportions. Europe, although it had great undeveloped oil-fields of its own, drew upon this new American enterprise to such an extent that, eleven years after Drake's "discovery," petroleum had taken fourth place among our exported articles.

The very year that Bissell had organized his petroleum company a boy of sixteen had obtained his first job in a produce commission office on a dock in Cleveland. As the curtain rises on the career of

John D. Rockefeller, we see him perched upon a high stool, adding up figures and casting accounts, faithfully doing every odd office job that came his way, earning his employer's respect for his industry, his sobriety, and his unmistakable talents for business. Nor does this picture inadequately visualize Rockefeller's whole after-life, and explain the business qualities that made possible his unexampled success. It is, indeed, the scene to which Mr. Rockefeller himself most frequently reverts when, in his famous autobiographical discourses to his Cleveland Sunday School, he calls our attention to the rules that inevitably lead to industrial prosperity. "Thrift, thrift, Horatio," is the one idea upon which the great captain of the oil business has always insisted. Many have detected in these habits of mind only the cheese-paring activities of a naturally narrow spirit. Rockefeller's old Cleveland associates remember him as the greatest bargainer they had ever known, as a man who had an eye for infinite details and an unquenchable patience and resource in making economies. Yet Rockefeller was clearly more than a pertinacious haggler over trifles. Certainly such a diagnosis does not explain a man who has built up one of the world's greatest organizations and accumulated

the largest fortune which has ever been placed at the disposal of one man. Indeed, Rockefeller displayed unusual business ability even before he entered the oil business. A young man who, at the age of nineteen, could start a commission house and do a business of nearly five hundred thousand the first year must have had commercial capacity to an extraordinary degree.

Fate had placed Rockefeller in Cleveland in the days when the oil business had got well under way. In the early sixties a score or so of refineries had started in this town, many of which were making large profits. It is not surprising that Rockefeller, gazing at these black and evil-smelling buildings from the vantage point of his commission office, should have felt an impulse to join in the gamble. He plunged into this new activity at the age of twenty-three. He possessed two great advantages over most of his adventurous competitors; one was a heavy bank account, representing his earnings in the commission business, and the other a partner, Samuel Andrews, who was generally regarded as a mechanical genius in the production of illuminating oil. At the beginning, therefore, Rockefeller had the two essentials which largely explain his subsequent career; an adequate liquid capital and

high technical resources. In the first few years the Rockefeller houses — he rapidly organized three, one after another — competed with a large number of other units in the oil business on somewhat more than even terms. At this time Rockefeller was merely one of a large number of successful oil refiners, yet during these early days a grandiose scheme was taking shape in that quiet, insinuating, far-reaching brain. He said nothing about it, even to his closest associates, yet it filled his every waking hour. For this young man was taking a comprehensive sweep of the world and he saw millions of people, in the Americas, in Europe, and in Asia, whose need for the article in which he dealt would grow more insistent every day. He saw that he was handling a product which was becoming as much a necessity of life as the air itself. The young man reached out to grasp this business. "All of it," we can picture Rockefeller saying to himself, "all of it shall be mine." Any study of Rockefeller's career must lead to the conclusion that, before he had reached his thirtieth year, he had determined to monopolize this growing necessity. The mere fact that this young man could form such a stupendous plan indicates that in him we are meeting for the first time a new type

of industrial leader. At that time monopolies were unknown in the United States. That certain old English Kings had frequently granted exclusive trading privileges to favored merchants most educated Americans knew; and their knowledge of monopolies extended little further than this. Yet about 1868 John D. Rockefeller started consciously to revive this ancient practice, and to bring under one ownership the magnificent industry to which Drake's sensational discovery had given rise.

Daring as was this conception, the resourcefulness and the skill with which Rockefeller executed it were more startling still. Merely to catalogue, one by one, the achievements of the ten succeeding fruitful years, almost takes one's breath away. Indeed the whole operation proceeded with such a Napoleonic rapidity of action that the outside world had hardly grasped Rockefeller's intention before the monopoly had been made complete. We catch one glimpse of Rockefeller, in 1868, as head of the prosperous house of Rockefeller, Andrews, and Flagler, and eight years afterwards we see him once more, this time the man who controlled practically the entire petroleum business of the world. His career of conquest began in 1870, when the firm of Rockefeller, Andrews, and Flagler, joining hands

with several large capitalists in Cleveland and New York, was incorporated under the name of the Standard Oil Company of Ohio. In 1870 about twenty-five independent refineries, many of them prosperous and powerful, were manufacturing oil in the city of Cleveland; two years afterward this new Standard Oil Company had absorbed all of them except five. In these two critical years the oil business of the largest refining center in the United States had thus passed into Rockefeller's hands. By 1874 the greatest refineries in New York and Philadelphia had likewise merged their identity with his own. When Rockefeller began his acquisition, there were thirty independent refineries operating in Pittsburgh, all of which, in four or five years, passed one by one under his control. The largest refineries of Baltimore surrendered in 1875.

These capitulations left only one important refining headquarters in the United States which the Standard had not absorbed. This was that section of western Pennsylvania where the oil business had had its origin. The mere fact that this area was the headquarters of the oil supply gave it great advantages as a place for manufacturing the finished product. The oil regions regarded these advantages as giving them the right to dominate the

growing industry, and they had frequently proclaimed the doctrine that the business belonged to them. They hated Rockefeller as much as they feared him, yet at the very moment when the Titusville operators were hanging him in effigy and posting the hoardings with cabalistic signs against his corporation, this mysterious, almost uncanny power was encircling them. Men who one night were addressing public meetings denouncing the Standard influence would suddenly sell out their holdings the next day. In 1875 John D. Archbold, a brilliant young refiner who had grown up in the oil regions and who had gained much local fame as opponent of the Standard, appeared in Titusville as the President of the Acme Oil Company. At that time there were twenty-seven independent refineries in this section. Archbold began buying and leasing these establishments for his Acme Company, and in about four years practically every one had passed under his control. The Acme Company was merely a subsidiary of the Standard Oil.

These rapid purchasing campaigns gave the Standard ninety per cent of all the refineries in the United States, but Rockefeller's scheme comprehended more than the acquisition of refineries. In the main the Rockefeller group left the production

of crude oil in the hands of the private drillers, but practically every other branch of the business passed ultimately into their hands. Both the New York Central and the Erie railroads surrendered to the Standard the large oil terminal stations which they had maintained for years in New York. As a consequence, the Standard obtained complete supervision of all oil sent by railroad into New York, and it also secured the machinery of a complete espionage system over the business of competitors. The Standard acquired companies which had built up a large business in marketing oil. Even more dramatic was its success in gathering up, one after another, these pipe lines which represented the circulatory system of the oil industry. In the early days these pipe lines were small and comparatively simple affairs. They merely carried the crude oil from the wells to railroad centers; from these stations the railroads transported it to the refineries at Cleveland, New York, and other places. At an early day the construction and management of these pipe lines became a separate industry. And now, in 1873, the Standard Oil Company secured possession of a one-third interest in the largest of these privately owned companies, the American Transfer Company. Soon afterward the

United Pipe Line Company went under their control. In 1877 the Empire Transportation Company, a large pipe line and refining corporation which the Pennsylvania Railroad had controlled for many years, became a Standard subsidiary.

Meanwhile certain hardy spirits in the oil regions had conceived a much more ambitious plan. Why not build great underground mains directly from the oil regions to the seaboard, pump the crude oil directly to the city refineries, and thus free themselves from dependence on the railroads? At first the idea of pumping oil through pipes over the Alleghany Mountains seemed grotesque, but competent engineers gave their indorsement to the plan. A certain "Dr." Hostetter built for the Columbia Conduit Company a trunk pipe line that extended thirty miles from the oil regions to Pittsburgh. Hardly had Hostetter completed his splendid project when the Standard Oil capitalists quietly appeared and purchased it! For four years another group struggled with an even more ambitious scheme, the construction of a conduit, five hundred miles long, from the oil regions to Baltimore. The American people looked on admiringly at the splendid enterprise whose projectors, led by General Haupt, the builder of the Hoosac Tunnel, struggled

against bankruptcy, strikes, railroad opposition, and hostile legislatures, in their attempts to push their pipe line to the sea. In 1879 the Tidewater Company first began to pump their oil, and the American press hailed their achievement as something that ranked with the laying of the Atlantic Cable and the construction of the Brooklyn Bridge. But in less than two years the Rockefeller interest had entered into agreements with the Tidewater Company that practically placed this great sea-board pipe line in its hands.

Thus in less than ten years Rockefeller had realized his ambitious dream; he now controlled practically everything concerned in the manufacture and sale of petroleum. The change had come about so stealthily, so secretly, and even so remorselessly that it impressed the public almost as the work of some uncanny genius. What were the forces, personal and economic, that had produced this new phenomenon in our business life? In certain particulars the Standard Oil monopoly was the product of well-understood principles. From his earliest days John D. Rockefeller had struggled to eliminate the middleman. He established factories to build his own barrels, to make his own acids; he created his own selling firms, and, instead of paying

large storage charges, he constructed his own warehouses in New York. From his earliest days as a refiner, he had adopted the principle of paying no man a profit, and of performing all the intermediate acts that had formerly resulted in large tribute to middlemen. Moreover, the Standard Oil Company was apparently the first great American industrial enterprise that realized the necessity of operating with an abundant capital. Not the least of Mr. Rockefeller's achievements was his success in associating with the new company men having great financial standing — Amasa Stone, Benjamin Brewster, Oliver Jennings, and the like, capitalists whose banking resources, placed at the disposition of the Standard, gave it an immense advantage over its rivals. While his competitors were "kiting" checks and waiting, hat in hand, on the good nature of the money lenders, Rockefeller always had a large bank balance, upon which he could instantly draw for his operations.

Nor must we overlook the fact that the Standard group contained a large number of exceedingly able men. "They are mighty smart men," said the despairing W. H. Vanderbilt, in 1879, when pressed to give his reasons for granting rebates to the Rockefeller group. "I guess if you ever had to deal

with them you would find that out." In Rockefeller the corporation possessed a man of tireless industry and unshakable determination. Nothing could turn him aside from the work to which he had put his hand. Public criticism and even denunciation, while he resented it as unjust and regarded it as the product of a general misunderstanding, never caused the leader of Standard Oil even momentarily to flinch. He was a man of one idea, and he worked at it day and night, taking no rest or recreation, skillfully turning to his purpose every little advantage that came his way. His associates — men like Flagler, Archbold, and Rogers — also had unusual talents, and together they built up the splendid organization that still exists. They exacted from their subordinates the last ounce of attention and energy and they rewarded generously everybody who served them well. They showed great judgment in establishing refineries at the most strategic points and in giving up localities, such as Boston and Portland, which were too far removed from their supplies. They established a marketing system which enabled them to bring their oil directly from their own refineries to the retailer, all in their own tank cars and tank wagons. They extended their markets in foreign countries,

so that now the Standard sells the larger part of its products outside the United States. They established chemical research laboratories which devised new and inexpensive methods for refining the product and developed invaluable by-products, such as paraffin, naphtha, vaseline, and lubricating oils. It is impossible to study the career of the Standard Oil Company without concluding that we have here an example of a supreme business intelligence working in a field which gave the widest possible scope of action.

A high quality of organization, however, does not completely explain the growth of this monopoly. The Standard Oil Company was the beneficiary of methods that have deservedly received great public opprobrium. Of these the one that stands forth most conspicuously is the railroad rebate. Those who have attempted to trace the very origin of the Rockefeller preëminence to railroad discrimination have not entirely succeeded. Only the most hazy evidence exists that the firm of Rockefeller, Andrews, and Flagler greatly profited from rebates. In fact, refined oil was not transported from Cleveland to the seaboard by railroad until 1870, the year that this firm dissolved; practically all of the product then went by way of the Great Lakes and

the Erie Canal. Possibly the Rockefeller firm did get occasional rebates on crude oil from the oil regions to the refineries, but so did their competitors. It is therefore not likely that such favors had great influence in making this single firm the most successful in the largest refining center. With the organization of the Standard Oil Company, however, rebates became a more important consideration.

The turning-point in the history of the oil industry came when the Rockefeller interests acquired the Cleveland refineries. The details concerning this act of generalship are fairly well known. The South Improvement Company is a corporation that necessarily bulks large in the history of the Standard Oil. Mr. Rockefeller and his associates have always disclaimed the parentage of this organization. They assert — and their assertion is doubtless true — that the only responsible begetters were Thomas A. Scott, President of the Pennsylvania Railroad, and certain refineries in Pittsburgh and Philadelphia which, though they were afterwards absorbed by the Standard, were at that time their competitors. These refiners and the Pennsylvania, over which the Standard Oil then was making no shipments, thus represented a group,

composed of railroads and refiners, which was antagonistic to the Rockefeller interests. The South Improvement Company was an association of refiners with which the railroads, chiefly the Pennsylvania, the New York Central, and the Erie, made exclusive contracts for shipping oil. Under these contracts rates to the seaboard were to be generally raised, though the members of the South Improvement Company were to receive liberal rebates. The refiners of Cleveland and Pittsburgh were to get lower rates than the refiners located in the oil regions. But the clause in these contracts that caused the greatest amazement and indignation was one which gave the inside group rebates on every barrel of oil shipped by its competitors.

It would be difficult to imagine any transaction more wicked than these contracts. Carried into execution they inevitably meant the extinction of every refiner who had not been admitted into the inside ring. Of the two thousand shares of the South Improvement Company, the gentlemen who were at that time most conspicuously identified with the Standard Oil Company subscribed to five hundred and forty. Mr. Rockefeller has always protested that he did not favor the scheme and that

he became a party to it simply because he could not afford to antagonize the powerful Pennsylvania Railroad, which had originated it. When the details became public property, a wave of indignation swept from the Atlantic to the Pacific; the oil regions, which would have been the heaviest sufferers, shut down their wells and so cut off the supply of crude oil; the New York newspapers started a "crusade" against the South Improvement group and Congress ordered an investigation. So fiercely was the public wrath aroused that the railroads ran to cover, abrogated the contracts, signed an agreement promising never more to grant rebates to any one, while the Pennsylvania Legislature repealed the charter of the South Improvement Company. This particular scheme, therefore, never came to maturity.

Before the South Improvement Company ended its corporate existence, however, a great change had taken place in the oil situation. Practically all the refineries in Cleveland had passed into the control of the Standard Oil Company. The Standard has always denied that there was any connection between the purchase of these great refineries and the organization of the South Improvement Company. But there is much evidence sustaining a

contrary view, for many of these refiners afterward went on the witness stand and told circumstantial stories, all of which made precisely the same point. This was that the Standard men had come to them, shown the contracts which had been made by the South Improvement Company, and argued that, under these new conditions, the refineries left outside the combination could not long survive. The Standard's rivals were therefore urged to "come in," to take Standard stock in return for their refineries, or, if they preferred, to sell outright. Practically all saw the force in this argument and sold — in most cases taking cash.

The acquisition of these Cleveland refineries made inevitable the Rockefeller conquest of the oil industry. Up to that time the Standard had refined about fifteen hundred barrels a day, and now suddenly its capacity jumped to more than twelve thousand barrels. This one strategic move had made Rockefeller master of about one-third of all the oil business in the United States, and this fact explains the rapidity with which the other citadels fell. There is no evidence that the Standard exercised any pressure upon the great refineries in New York, Pittsburgh, and Philadelphia. Indeed these concerns manifested an eagerness to join. The

fact that, unlike the Cleveland refiners, many of the firms in these other cities took Standard stock, and so became parts of the new organization, is in itself significant. They evidently realized that they were casting their fortunes with the winning side. The huge shipments which the Standard now controlled explain this change in front. Every day Mr. Rockefeller could send from Cleveland to the seaboard a train, sixty cars long, loaded with the blue barrels containing his celebrated liquid. That was a consideration for which any railroad would at that time sell its soul. And the New York Central road promptly made this sacrifice. Hardly had the ink dried on its written promise not to grant any rebates when it began granting them to the Standard Oil Company.

In those days the railroad rate was not the sacred, immutable thing which it subsequently became, although the argument for equal treatment of shippers existed theoretically just as strongly forty years ago as it does today. The rebate was just as illegal then as it is at present; there was no precise statute, it is true, which made it unlawful until the Interstate Commerce Act was passed in 1887; but the common law had always prohibited such discriminations. In the seventies

and eighties, however, railroad men like Cornelius Vanderbilt and Thomas A. Scott were less interested in legal formalities than in getting freight. They regarded transportation as a commodity to be bought and sold, like so much sugar or wheat or coal, and they believed that the ordinary principles which regulated private bargaining should also regulate the sale of the article in which they dealt. According to this reasoning, which was utterly false and iniquitous, but generally prevalent at the time, the man who shipped the largest quantities of oil should get the lowest rate.

The purchase of the Cleveland refineries made the Standard Oil group the largest shippers and therefore they obtained the most advantageous terms for transporting their product. Under these conditions they naturally obtained the monopoly, the extent of which has been already described. Their competitors could rage, hold public meetings, start riots, threaten to lynch Mr. Rockefeller and all his associates, but they could not long survive in face of these advantages. The only way in which the smaller shippers could overcome this handicap was by acquiring new methods of transportation. It was this necessity that inspired the construction of pipe lines; but the Standard, as already de-

scribed, succeeded in absorbing these just about as rapidly as they were constructed.

Not only did the Standard obtain railroad rebates but it developed the most death-dealing methods in its system of marketing its oil. In these campaigns it certainly overstepped the boundaries of legitimate business, even according to the prevailing morals of its own or of any other time. While it probably did not set fire to rival refineries, as it has sometimes been accused of doing, it undoubtedly did resort to somewhat Prussian methods of destroying the foe. This great corporation divided the United States into several sections, over each of which it appointed an agent, who in turn subdivided his territory into smaller divisions, each one of which likewise had its captain. The order imperatively issued to each agent was, "Sell all the oil that is sold in your district." To these instructions he was rigidly held; success in accomplishing his task meant advancement and an increased salary, with a liberal pension in his old age, whereas failure meant a pitiless dismissal. He was expected to supervise not only his own business, but that of his rivals as well, to obtain access to their accounts, their shipments, and their customers. It has been asserted, and the assertion

has been supported by considerable evidence, that these agents did not hesitate to bribe railroad employees and in this way get access to their competitors' bills of lading and records of their shipments, and that they would even bribe dealers to cancel such orders and take the oil from them at a lower price. This information laid the foundation for those price-cutting campaigns that have brought the name of the Standard Oil into such disfavor. And when the Standard cut, it cut to kill; the only purpose was to drive the competitor from the field, and, when this had been accomplished, the price of oil would promptly go up again. The organization of "bogus companies," started purely for the purpose of eliminating competitors, seems to have been a not infrequent practice. This latter method emphasizes another quality that accompanied the Standard's operations and so largely explains its unpopularity — the secrecy with which it so commonly worked. Though the independent oil refiners were combating the most powerful financial power of the time, they were frequently fighting in the dark, never knowing where to deliver their blows.

This same characteristic was manifested in the form of corporate existence which the Standard

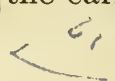
adopted. The first great "trust" was a trust not only in name but in fact. The Standard introduced not only a new economic development into our national organization; it introduced a new word into our language and an issue into American politics that provided sustenance for the presidential campaigns of twenty-five years. From the beginning the Standard Oil had always been a close corporation. Originally it had had only ten stockholders, and this number had gradually grown until, in 1881, there were forty-one. These men had adopted a new and secretive method of combining their increasing possessions into a single ownership. In 1873 the Standard Company had increased its capital stock (originally \$1,000,000) to \$3,500,000, the new certificates being exchanged for interests in the great New York and Philadelphia refineries. The Standard Oil Company of Ohio never had a larger capital stock than that. As additional properties were acquired, the interests were placed in the hands of trustees, who held them for the joint benefit of the stockholders in the original company. In 1882 this idea was carried further, for then the Standard Oil Trust was organized. The fact that the properties lay in so many different States, many of which had laws intended to curb corporations,

was evidently what led to this form of consolidation. A trust was formed, consisting of nine trustees, who held, for the benefit of the Standard Oil stockholders, all the stock in the Standard and in the subsidiary companies. Instead of certificates of stock the trustees issued certificates of trust amounting to \$70,000,000. Each Standard stockholder received twenty of these certificates for each share which he held of Standard stock. These certificates could be bought and sold and passed on by inheritance precisely the same as stocks.

Ingenious as was this legal device, it did not stand the test of the courts. In 1892 the Ohio Supreme Court declared the Standard Oil Trust a violation of the law and demanded its dissolution. The persistent attempts of the Standard to disregard this order increased its reputation for lawlessness. Finally, in 1899, after Ohio had brought another action, the trust was dissolved. The Standard interests now reorganized all their holdings under the name of the Standard Oil Company of New Jersey. Again, in 1911, the United States Supreme Court declared this combination a violation of the Sherman Anti-Trust Act, and ordered its dissolution. By this time the Standard capitalists had learned the value of public opinion as a corpo-

rate asset, and made no attempt to evade the order of the court. The Standard Oil Company of New Jersey proceeded to apportion among its stockholders the stock which it held in thirty-seven other companies — refineries, pipe lines, producing companies, marketing companies, and the like. Chief Justice White, in rendering his decision, specifically ordered that, in dissolving their combination, the Standard should make no agreement, contractual or implied, which was intended still to retain their properties in one ownership. As less than a dozen men owned a majority interest in the Standard Oil Company of New Jersey, these same men naturally continued to own a majority interest in the subsidiary companies. Though the immediate effect of this famous decision therefore was not to cause a separation in fact, this does not signify that, as time goes on, such a real dissolution will not take place. It is not unlikely that, in a few years, the transfers of the stock by inheritance or sale will weaken the consolidated interest to a point where the companies that made up the Standard Company will be distinct and competitive.

This is more likely to be the case since, long before the decision of 1911, the Standard Oil Company had ceased to be a monopoly. In the early nine-



ties there came to the front in the oil regions a man whose organizing ability and indomitable will suggested the Standard Oil leaders themselves. This man's soul burned with an intense hatred of the Rockefeller group, and this sentiment, as much as his love of success, inspired all his efforts. There is nothing finer in American business history than the fifteen years' battle which Lewis Emery, Jr., fought against the greatest financial power of the day. In 1901 this long struggle met with complete success. Its monuments were the two great trunk pipe lines which Emery had built from the Pennsylvania regions to Marcus Hook, near Philadelphia, one for pumping refined and one for pumping crude. The Pure Oil Company, Emery's creation, has survived all its trials and has done an excellent business. And meanwhile other independents sprang up with the discovery of oil in other parts of the country. This discovery first astonished the Standard Oil men themselves; when someone suggested to Archbold, thirty-five years ago, that the mid-continent field probably contained large oil supplies, he laughed, and said that he would drink all the oil ever discovered outside of Pennsylvania. In these days a haunting fear pursued the oil men that the Pennsylvania field

would be exhausted and that their business would be ended. This fear, as developments showed, had a substantial basis; the Pennsylvania yield began to fail in the eighties and nineties, until now it is an inconsiderable element in this gigantic industry. Ohio, Indiana, Illinois, Kansas, Oklahoma, Texas, California, and other States in turn became the scene of the same exciting and adventurous events that had followed the discovery of oil in Pennsylvania. The Standard promptly extended its pipe lines into these new areas, but other great companies also took part in the development. These companies, such as the Gulf Refining Company and the Texas Refining Company, have their gathering pipe lines, their great trunk lines, their marketing stations, and their export trade, like the Standard; the Pure Oil Company has its tank cars, its tank ships, and its barges on the great rivers of Europe. The ending of the rebate system has stimulated the growth of independents, and the production of crude oil and the market demand in a thousand directions has increased the business to an extent which is now far beyond the ability of any one corporation to monopolize. The Standard interests refine perhaps something more than fifty per cent of the crude oil produced in this country.

But in recent years, Standard Oil has meant more than a corporation dealing in this natural product. It has become the synonym of a vast financial power reaching in all directions. The enormous profits made by the Rockefeller group have found investments in other fields. The Rockefellers became the owners of the great Mesaba iron ore range in Minnesota and of the Colorado Fuel and Iron Company, the chief competitor of United States Steel. It is the largest factor in several of the greatest American banks. Above all, it is the single largest railroad power in America today.

CHAPTER III

THE EPIC OF STEEL

IT was the boast of a Roman Emperor that he had found the Eternal City brick and left it marble. Similarly the present generation of Americans inherited a country which was wood and have transformed it into steel. That which chiefly distinguishes the physical America of today from that of forty years ago is the extensive use of this metal. Our fathers used steel very little in railway transportation; rails and locomotives were usually made of iron, and wood was the prevailing material for railroad bridges. Steel cars, both for passengers and for freight, are now everywhere taking the place of the more flimsy substance. We travel today in steel subways, transact our business in steel buildings, and live in apartments and private houses which are made largely of steel. The steel automobile has long since supplanted the wooden carriage; the steel ship has displaced the iron

and wooden vessel. The American farmer now encloses his lands with steel wire, the Southern planter binds his cotton with steel ties, and modern America could never gather her abundant harvests without her mighty agricultural implements, all of which are made of steel. Thus it is steel that shelters us, that transports us, that feeds us, and that even clothes us.

This substance is such a commonplace element in our lives that we take it for granted, like air and water and the soil itself; yet the generation that fought the Civil War knew practically nothing of steel. They were familiar with this metal only as a curiosity or as a material used for the finer kinds of cutlery. How many Americans realize that steel was used even less in 1865 than aluminum is used today? Nearly all the men who have made the American Steel Age—such as Carnegie, Phipps, Frick, and Schwab—are still living and some of them are even now extremely active. Thirty-five years ago steel manufacture was regarded, even in this country, as an almost exclusively British industry. In 1870 the American steel maker was the parvenu of the trade. American railroads purchased their first steel rails in England, and the early American steel makers went to Sheffield for

their expert workmen. Yet, in little more than ten years, American mills were selling agricultural machinery in that same English town, American rails were displacing the English product in all parts of the world, American locomotives were drawing English trains on English railways, and American steel bridges were spanning the Ganges and the Nile. Indeed, the United States soon surpassed England. In the year before the World War the United Kingdom produced 7,500,000 tons of steel a year, while the United States produced 32,000,000 tons. Since the outbreak of the Great War, the United States has probably made more steel than all the rest of the world put together. "The nation that makes the cheapest steel," says Mr. Carnegie, "has the other nations at its feet." When some future Buckle analyzes the fundamental facts in the World War, he may possibly find that steel precipitated it and that steel determined its outcome.

Three circumstances contributed to the rise of this greatest of American industries: a new process for cheaply converting molten pig iron into steel, the discovery of enormous deposits of ore in several sections of the United States, and the entrance into the business of a hardy and adventurous group of

manufacturers and business men. Our steel industry is thus another triumph of American inventive skill, made possible by the richness of our mineral resources and the racial energy of our people. An elementary scientific discovery introduced the great steel age. Steel, of course, is merely iron which has been refined — freed from certain impurities, such as carbon, sulphur, and phosphorus. We refine our iron and turn it into steel precisely as we refine our sugar and petroleum. From the days of Tubal Cain the iron worker had known that heat would accomplish this purification; but heat, up to almost 1865, was an exceedingly expensive commodity. For ages iron workers had obtained the finer metal by applying this heat in the form of charcoal, never once realizing that unlimited quantities of another fuel existed on every hand. The man who first suggested that so commonplace a substance as air, blown upon molten pig iron, would produce the intensest heat and destroy its impurities, made possible our steel railroads, our steel ships, and our steel cities. When William Kelly, an owner of iron works near Eddyville, Kentucky, first proposed this method in 1847, he met with the ridicule which usually greets the pioneer inventor. When Henry Bessemer, several years

afterward, read a paper before the British Association for the Advancement of Science, in which he advocated the same principle, he was roared down as "a crazy Frenchman," and the savants were so humiliated by the suggestion that they voted to make no record of his "silly paper" in their official minutes. Yet these two men, the American Kelly and the Englishman Bessemer, were the creators of modern steel. The records of the American Patent Office clearly show that Kelly made "Bessemer" steel many years before Bessemer. In 1870 the American Government refused to extend Bessemer's patent in this country on the ground that William Kelly had a prior claim; in spite of this, Bessemer was undoubtedly the man who developed the mechanical details and gave the process a universal standing.

Though the Bessemer process made possible the production of steel by tons instead of by pounds, it would never in itself have given the nation its present preëminence in the steel industry. Iron had been mined in the United States for two centuries on a small scale, the main deposits being located in the Lake Champlain region of New York and in western Pennsylvania. But these, and a hundred other places located along the Atlantic coast, could

not have produced ore in quantities sufficient to satisfy the yawning jaws of the Bessemer converters. As this new method poured out the liquid in thousands of tons, and as the commercial demand extended in a dozen different directions, the cry went up from the furnaces for more ore. And again Nature, which has favored America in so many directions, came to her assistance. Manufacturers in the steel regions began to recall strange stories which had been floating down for many years from the wilderness surrounding Lake Superior. The recollection of a famous voyage made in this region by Philo M. Everett, as far back as 1845, now laid siege to the imagination of the new generation of ironmasters. For years the Indians had told Everett of the "mountains of iron" that lay on the Minnesota shore of Lake Superior and had described their wonders in words that finally impelled this hardy adventurer to make a voyage of exploration. For six weeks, in company with two Indian guides, Everett had navigated a small boat along the shores of the Lake, covering a distance that now takes only a few hours. The Indians had long regarded this silent, red iron region with a superstitious reverence, and now, as the little party approached, they refused to complete the journey.

“Iron Mountain!” they said, pointing northward along the trail — “Indian not go near; white man go!” The sight which presently met Everett’s eyes repaid him well for his solitary tramp in the forest. He found himself face to face with a “mountain a hundred and fifty feet high, of solid ore, which looked as bright as a bar of iron just broken.” Other explorations subsequently laid open the whole of the Minnesota fields, including the Mesabab, which developed into the world’s greatest iron range. America has other regions rich in ore, particularly in Alabama, located alongside the coal and limestone so necessary in steel production; yet it has drawn two-thirds of its whole supply from these Lake Superior fields. Not only the quantity, which is apparently limitless, but the quality explains America’s leadership in steel making.

Mining in Minnesota has a character which is not duplicated elsewhere. When we think of an iron mine, we naturally picture subterranean caverns and galleries, and strange, gnome-like creatures prowling about with pick and shovel and drill. But mining in this section is a much simpler proceeding. The precious mineral does not lie concealed deep within the earth; it lies practically upon the surface. Removing it is not a question of blasting

with dynamite; it is merely a matter of lifting it from the surface of the earth with a huge steam shovel. "Miners" in Minnesota have none of the conventional aspects of their trade. They operate precisely as did those who dug the Panama Canal. The railroad cars run closely to the gigantic red pit. A huge steam shovel opens its jaws, descends into an open amphitheater, licks up five tons at each mouthful, and, swinging sideways over the open cars, neatly deposits its booty. It is not surprising that ore can be produced at lower cost in the United States than even in those countries where the most wretched wages are paid. Evidently this one iron field, to say nothing of others already worked, gives a permanence to our steel industry.

Not only did America have the material resources; what is even more important, she had also the men. American industrial history presents few groups more brilliant, more resourceful, and more picturesque than that which, in the early seventies, started to turn these Minnesota ore fields into steel — and into gold. These men had all the dash, all the venturesomeness, all the speculative and even the gambling instinct, needed for one of the greatest industrial adventures in our annals. All had sprung from the simplest and humblest

origins. They had served their business apprenticeships as grocery clerks, errand boys, telegraph messengers, and newspaper gamins. For the most part they had spent their boyhood together, had played with each other as children, had attended the same Sunday schools, had sung in the same church choirs, and, as young men, had quarreled with each other over their sweethearts. The Pittsburgh group comprised about forty men, most of whom retired as millionaires, though their names for the most part signify little to the present-day American. Kloman, Coleman, McCandless, Shinn, Stewart, Jones, Vandervoort — are all important men in the history of American steel. Thomas A. Scott and J. Edgar Thomson, men associated chiefly with the creation of the Pennsylvania Railroad, also made their contributions. But three or four men towered so preëminently above their associates that today when we think of the human agencies that constructed this mighty edifice, the names that insistently come to mind are those of Carnegie, Phipps, Frick, and Schwab.

Books have been written to discredit Carnegie's work and to picture him as the man who has stolen success from the labor of greater men. Yet Carnegie is the one member of a brilliant company who had

the indispensable quality of genius. He had none of the plodding, painstaking qualities of a Rockefeller; he had the fire, the restlessness, the keen relish for adventure, and the imagination that leaped far in advance of his competitors which we find so conspicuous in the older Vanderbilt. Carnegie showed these qualities from his earliest days. Driven as a child from his Scottish home by hunger, never having gone to school after twelve, he found himself, at the age of thirteen, living in a miserable hut in Allegheny, earning a dollar and twenty cents a week as bobbin-boy in a cotton mill, while his mother augmented the family income by taking in washing. Half a dozen years later Thomas Scott, President of the Pennsylvania Railroad, made Carnegie his private secretary. How well the young man used his opportunities in this occupation appeared afterward when he turned his wide acquaintanceship among railroad men to practical use in the steel business. It was this personal adaptability, indeed, that explains Carnegie's success. In the narrow, methodical sense he was not a business man at all; he knew and cared nothing for its dull routine and its labyrinthine details. As a practical steel man his position is a negligible one. Though he was profoundly impressed by his first

sight of a Bessemer converter, he had little interest in the every-day process of making steel. He had also many personal weaknesses: his egotism was marked, he loved applause, he was always seeking opportunities for self-exploitation, and he even aspired to fame as an author and philosopher. The staid business men of Pittsburgh early regarded Carnegie with disfavor; his daring impressed them as rashness and his bold adventures as the plunging of the speculator. Yet in all its aspects Carnegie's triumph was a personal one. He was perhaps the greatest commercial traveler this country has ever known. While his more methodical associates plodded along making steel, Carnegie went out upon the highway, bringing in orders by the millions. He showed this same personal quality in the organization of his force. As a young man, entirely new to the steel industry, he selected as the first manager of his works Captain Bill Jones; his amazing judgment was justified when Jones developed into America's greatest practical genius in making steel. "Here lies the man" — Carnegie once suggested this line for his epitaph — "who knew how to get around him men who were cleverer than himself." Carnegie inspired these men with his own energy and restlessness; the spirit of the whole establishment

automatically became that of the pushing spirit of its head. This little giant became the most remorseless pace-maker in the steel regions. However astounding might be the results obtained by the Carnegie works the captain at the head was never satisfied. As each month's output surpassed that which had gone before, Carnegie always came back with the same cry of "More." "We broke all records for making steel last week!" a delighted superintendent once wired him and immediately he received his answer, "Congratulations. Why not do it every week?" This spirit explains the success of the Carnegie Company in outdistancing all its competitors and gaining a world-wide preëminence for the Pittsburgh district. But Carnegie did not make the mistake of capitalizing all this prosperity for himself; his real greatness as an American business man consists in the fact that he liberally shared the profits with his associates. Ruthless he might be in appropriating their last ounce of energy, yet he rewarded the successful men with golden partnerships. Nothing delighted Carnegie more than to see the man whom he had lifted from a puddler's furnace develop into a millionaire.

Henry Phipps, still living at the age of seventy-

eight, was the only one of Carnegie's early associates who remained with him to the end. Like many of the others, Phipps had been Carnegie's playmate as a boy, so far as any of them, in those early days, had opportunity to play; like all his contemporaries also, Phipps had been wretchedly poor, his earliest business opening having been as messenger boy for a jeweler. Phipps had none of the dash and sparkle of Carnegie. He was the plodder, the bookkeeper, the economizer, the man who had an eye for microscopic details. "What we most admired in young Phipps," a Pittsburgh banker once remarked, "is the way in which he could keep a check in the air for three or four days." His abilities consisted mainly in keeping the bankers complaisant, in smoothing the ruffled feelings of creditors, in cutting out unnecessary expenditures, and in shaving prices.

Carnegie's other two more celebrated associates, Henry C. Frick and Charles M. Schwab, were younger men. Frick was cold and masterful, as hard, unyielding, and effective as the steel that formed the staple of his existence. Schwab was enthusiastic, warm-hearted, and happy-go-lucky; a man who ruled his employees and obtained his results by appealing to their sympathies. The men

of the steel yards feared Frick as much as they loved "Charlie" Schwab. The earliest glimpses which we get of these remarkable men suggest certain permanent characteristics: Frick is pictured as the sober, industrious bookkeeper in his grandfather's distillery; Schwab as the rollicking, whistling driver of a stage between Loretto and Cresson. Frick came into the steel business as a matter of deliberate choice, whereas Schwab became associated with the Pittsburgh group more or less by accident.

The region of Connellsville contains almost 150 square miles underlaid with coal that has a particular heat value when submitted to the process known as coking. As early as the late eighties certain operators had discovered this fact and were coking this coal on a small scale. It is the highest tribute to Frick's intelligence that he alone foresaw the part which this Connellsville coal was to play in building up the Pittsburgh steel district. The panic of 1873, which laid low most of the Connellsville operators, proved Frick's opportunity. Though he was only twenty-four years old he succeeded, by his intelligence and earnestness, in borrowing money to purchase certain Connellsville mines, then much depreciated in price. From that

moment, coke became Frick's obsession, as steel had been Carnegie's. With his early profits he purchased more coal lands until, by 1889, he owned ten thousand coke ovens and was the undisputed "coke king" of Connellsville. Several years before this, Carnegie had made Frick one of his marshals, coke having become indispensable to the manufacture of steel, and in 1889 the former distiller's accountant became Carnegie's commander-in-chief. Probably the popular mind associates Frick chiefly with the importation of Slavs as workmen, with the terrible strikes that followed in consequence at Homestead, with the murderous attack made upon him by Berkman, the anarchist, and with his bitter, long-drawn-out quarrel with Andrew Carnegie. Frick's stormy career was naturally the product of his character.

On the other hand, temperamental pliability and loveliness were the directing traits of the man who, in his way, made contributions quite as solid to the extension of the Pittsburgh steel industry. Schwab worked with the human material quite as successfully as other men worked with iron ore, Bessemer furnaces, and coal. He handled successfully what was perhaps the greatest task in management ever presented to a manufacturer

when to him fell the job of reorganizing the Homestead Works after the strike of 1892 and of transforming thousands of riotous workmen into orderly and interested producers of steel. In three or four years practically every man on the premises had become "Charlie" Schwab's personal friend, and the Homestead property which, until the day he took charge, had been a colossal failure, had developed into one of the most profitable holdings of the Carnegie Company. As his reward Schwab, at the age of thirty-four, was made President of the Carnegie corporation. Only sixteen years before he had entered the steel works as a stake driver at a dollar a day.

When the Carnegie group began operations in the early seventies, American steel, as a British writer remarked, was a "hot-house product"; yet in 1900 the Carnegie partners divided \$40,000,000 as the profits of a single year. They had demonstrated that the United States, despite the high prices that prevailed everywhere, could make steel more cheaply than any other country. Foreign observers have offered several explanations for this achievement. American makers had an endless supply of cheap and high-grade ore, cheaper coke, cheaper transportation, and workmen of a superior

skill. We must give due consideration to the fact that their organization was more flexible than those of older countries, and that it regulated promotion exclusively by merit and gave exceptional opportunities to young men. American steel makers also had scrap heaps whose size astounded the foreign observers; they never hesitated to discard the most expensive plants if by so doing they could reduce the cost of steel rails by a dollar a ton. Machinery for steel making had a more extensive development in this country than in England or Germany. Mr. Carnegie also enjoyed the advantages of a high protective tariff, though about 1900 he discovered that his extremely healthy infant no longer demanded this form of coddling. But probably the Carnegie Company's greatest achievement was the abolition of the middleman. In a few years it assembled all the essential elements of steel making in its own hands. Frick's entrance into the combination gave the concern an unlimited supply of the highest grade of coking coal. In a few years, the Carnegie interests had acquired great holdings in the Minnesota ore regions.

At first glance, the Pittsburgh region seems hardly the ideal place for the making of steel. Fortune first placed the industry there because all the

raw materials, especially iron ore and coal, seemed to exist in abundance. But the discovery of the Minnesota ore field, which alone could supply this essential product in the amounts which the furnaces demanded, immediately deprived the Pittsburgh region of its chief advantage. As a result of this sudden development, the manufacturers of Pittsburgh awoke one morning and discovered that their ore was located a thousand miles away. To bring it to their converters necessitated a long voyage by water and rail, with several reloadings. They overcame these obstacles by developing machinery for handling ore and by acquiring the raw materials and the connecting links of transportation. Ore which had been lying in the wilds of Minnesota on Monday morning was thus brought to Pittsburgh and made into steel rails or bridges or structural shapes by Saturday night. The Carnegie Company first acquired sufficient mineral lands to furnish ore for several generations and organized an ore fleet which transported the products of the mines through the lakes to ports on Lake Erie, particularly Ashtabula and Conneaut. The purchase of the Bessemer and Lake Erie Railroad, which extended from Conneaut to Pittsburgh, made this great transportation route complete. Besides

freeing their business from uncertainty, this elimination of middlemen naturally produced great economies.

Probably Andrew Carnegie's shrewdness in naming his first plant the J. Edgar Thompson Steel Works, after the powerful President of the Pennsylvania Railroad, and in making Thompson and his associate Scott partners, had much to do with his early success. These two gentlemen conferred two priceless favors upon the struggling enterprise. They became large purchasers of steel rails and their influence in this direction extended far beyond the Pennsylvania Railroad. What was perhaps even more important, they gave the Carnegie concerns railroad rebates. The use of rebates, as a method of stifling competition and building up a great industrial prosperity, is an offense which the popular mind associates almost exclusively with the Standard Oil Company, yet the Carnegie fortune, as well as that of John D. Rockefeller, received an artificial stimulation of this kind.

Though incomparably the greatest of the American steel companies, the Carnegie Steel Company by no means monopolized the field. In forty years, indeed, an enormous steel area had grown up, including western Pennsylvania, Ohio, Indiana, and

Illinois, practically all of it drawing its raw materials from those same teeming ore lands in the Lake Superior region. Johnstown, Youngstown, Cleveland, Lorain, Chicago, and Joliet, became headquarters of steel production almost as important as Pittsburgh itself. Two entirely new steel kingdoms, each with its own natural reservoirs of ore, grew up in Colorado and Alabama. The Colorado Fuel and Iron Company, which possessed apparently inexhaustible mineral lands in Colorado, Wyoming, Utah, New Mexico, and California, itself produces not far from three million tons a year, almost half the present production of Great Britain. The Alabama steel country has developed in even more spectacular fashion. Birmingham, a hive of southern industry placed almost as if by magic in the leisurely cotton lands of the South, had no existence in 1870, when the Pittsburgh prosperity began. In the Civil War, the present site of a city with a population of 140,000 was merely a blacksmith shop in the fork of the roads. Yet this district has advantages for the manufacture of steel that have no parallel elsewhere. The steel companies which are located here do not have to bring their materials laboriously from a distance but possess, immediately at hand, apparently endless store of the

three things needful for making steel — iron ore, coal, and limestone. All these territories have their personal romances and their heroes, many of them quite as picturesque as those of the Pittsburgh group.

It is doubtful indeed if American industry presents any figure quite as astonishing and variegated as that of John W. Gates, the man who educated farmers all over the world to the use of wire fencing. Half charlatan, half enthusiast, speculator, gambler, a man who created great enterprises and who also destroyed them, at times an up-building force and at other times a sinister influence, Gates completely typified a period in American history that, along with much that was heroic and splendid, had much also that was grotesque and sordid. The opera-bouffe performance that laid the foundations of Gates's great industry was in every way characteristic of this period. In 1871 Gates, then a clerk in a hardware store at twenty-five dollars a week, made his first attempt to sell barbed wire in the great cattle countries of the southwestern States. When the cattle men in Texas first saw this barbed wire, they ridiculed the idea that it could ever hold their steers. Gates selected a plaza in San Antonio, fenced it in with his new product, and invited the

enemies to bring along their wildest specimens. About thirty of Texas' most ferocious cattle, placed within the enclosure, spent a whole afternoon plunging at the barbs in a useless and tormenting attempt to escape. This spectacular demonstration of efficiency launched Gates fairly upon his career. He immediately began to sell his new fencing on an enormous scale; in a few years the whole world was demanding it, and it has become, as recent events have disclosed, a particularly formidable munition of war. The American Steel and Wire Company, one of the greatest of American corporations, was the ultimate outgrowth of that lively afternoon in San Antonio.

In 1900 the Carnegie Steel Company was making one-quarter of all the Bessemer steel produced in the United States. It owned in abundance all the properties which were essential to its completed output — coal, limestone, steel ships, railroads, and steel mills. In twenty-five years, from 1875 to 1900, this manufacturing enterprise had paid the Carnegie group profits aggregating \$133,000,000, profits which, in the closing years of the century, had increased at a stupendous rate. In 1898 Carnegie and his associates had divided \$11,500,000, in 1899 their earnings had grown to \$25,000,000, and

in 1900 the aggregate had suddenly jumped to \$40,000,000. Of this latter sum Carnegie received \$25,000,000, Phipps \$5,500,000, Frick \$2,600,000, and Schwab \$1,300,000. And Carnegie's little group could see no limit to the growth of their business and the expansion of their personal fortunes. Yet at that very moment Carnegie was planning to play the part of a Charles V. with the large empire which he had pieced together—to abdicate his throne, retire from business life, and spend his remaining days in quiet.

Many influences were impelling him to this decision. His triumph, stupendous as it had been, also had had its alloy of sorrow. Indeed this little Scotsman, now at the crowning of his glory, was one of the loneliest figures in the world. Practically all the forty men with whom he had been closely associated had vanished from the scene. He had quarreled with his playmate and lifelong partner, Henry Phipps, and was in the worst possible business and personal relations with Frick. He had no son to carry on his work. He had become greatly interested in his philanthropies, and he had declared that the man who died rich died disgraced. Moreover, new influences were rising in the steel trade with which Carnegie had little

sympathy. Its national capital seemed to be shifting from Pittsburgh to Wall Street. New men who knew nothing about steel but who possessed an intimate acquaintance with stocks and bonds — J. Pierpont Morgan, George W. Perkins, and their associates — were branching out as controllers of large steel interests. Carnegie had no interest in Wall Street; he has declared that he never speculated in his life and that he would immediately dissociate himself from any partner who would do so. This Wall Street coterie, in the years from 1898 to 1900, had made several large combinations in the steel trade. That was the era when the trust mania had gained possession of the American mind and when its worst features displayed themselves. The Federal Steel Company, the American Bridge Company, the American Steel and Wire, the National Tube Company, all representing the assembling of large works which had been engaged as rivals in similar enterprises, were launched, with the usual accompaniments of "underwriting syndicates," watered stock, and Wall Street speculation. This sort of thing made no appeal to Andrew Carnegie. His huge enterprise had always remained essentially a copartnership, and he had frequently expressed his abhorrence of trusts.

Yet, in spite of his wish to retire from business and in spite of his avowed intention to die poor, Carnegie now adopted the policy of the Sibylline leaves to all prospective purchasers. Moore and Reid would have purchased his interest for \$157,000,000; when Rockefeller came along the price had risen to \$250,000,000; when the oil man shook his head and retired, Carnegie immediately raised his price to \$500,000,000. It is doubtful whether he would have sold at all had not his Wall Street competitors begun to encroach on a field which the little Scotsman understood quite as well as they — the production and merchandising of steel. The newly organized combinations were completing elaborate plans to go after Carnegie's business. Then Carnegie, who had practically retired from active life, again arrayed himself in his shirt-sleeves, abandoned his career of authorship, and resumed his early trade. His first attacks produced an immense reverberation in the House of Morgan. He purchased a huge tract at Conneaut and began building a gigantic plant for the manufacture of steel tubes, a business in which he had not hitherto engaged. This was a blow aimed at one of Morgan's pet new creations, the National Tube Company. Should Carnegie finish his works, there

was no doubt the Morgan enterprise would be ruined, for the new plant would be far more modern and so could manufacture the product at a much lower price; and, with Charles M. Schwab as active manager, what possible chance would the older corporation have? But Carnegie struck his enemy at an even more vulnerable point. The Pennsylvania Railroad had a practical monopoly of traffic in and out of Pittsburgh, and Pittsburgh "created" more freight business than any other city in the world. Carnegie lent his powerful support to George J. Gould, who was then extending his railroad system into the preëmpted field and was also making surveys and had financed a company to build an entirely new railroad from Pittsburgh to the Atlantic Coast. As Carnegie himself controlled the larger part of the freight that made Pittsburgh such an essential feeder to railroads, his new enterprise caused the greatest alarm. At the same time Carnegie equipped a new and splendid fleet of ore ships, his purpose being to enter a field of transportation which John D. Rockefeller had found extremely profitable.

Such were the circumstances and such were the motives that gave birth to the world's largest corporation. All one night, so the story goes, Charles

M. Schwab and John W. Gates discussed the steel situation with J. Pierpont Morgan. There was only one possible solution, they said — Andrew Carnegie must be bought out. By the time the morning sun came through the windows Morgan had been convinced. “Go and ask him what he will sell for,” he said to Schwab. In a brief period Schwab came back to Morgan with a letter which contained the following figures — five per cent gold bonds \$303,450,000; preferred stock \$98,277,100; common stock \$90,279,000 — a total of over \$492,000,000. Carnegie demanded no cash; he preferred to hold a huge first mortgage on a business whose golden opportunities he knew so well. Morgan, who had been accustomed all his life to dictate to other men, had now met a man who was able to dictate to him. And he capitulated. The man who fifty-three years before had started life in a new country as a hobbin-boy at a dollar and twenty cents a week, now at the age of sixty-six retired from business the second richest man in the world. With him retired a miscellaneous assortment of millionaires whose fortunes he had made and whose subsequent careers in the United States and in Europe have given a peculiar significance to the name “Pittsburgh Millionaires.” The United

States Steel Corporation, the combination that included not only the Carnegie Company but seventy per cent of all the steel concerns in the country, was really a trust made up of trusts. It had a capitalization of a billion and a half, of which about \$700,000,000 was composed of the commodity usually known as "water"; but so greatly has its business grown and so capably has it been managed that all this liquid material has since been converted into more solid substance. The disappearance of Andrew Carnegie and his coworkers and the emergence of this gigantic enterprise completed the great business cycle in the steel trade. The age of individual enterprise and competition had passed — that of corporate control had arrived.

CHAPTER IV

THE TELEPHONE: "AMERICA'S MOST POETICAL ACHIEVEMENT"

A DISTINGUISHED English journalist, who was visiting the United States, in 1917, on an important governmental mission, had an almost sublime illustration of the extent to which the telephone had developed on the North American Continent. Sitting at a desk in a large office building in New York, Lord Northcliffe took up two telephone receivers and placed one at each ear. In the first he heard the surf beating at Coney Island, New York, and in the other he heard, with equal distinctness, the breakers pounding the beach at the Golden Gate, San Francisco. Certainly this demonstration justified the statement made a few years before by another English traveler. "What startles and frightens the backward European in the United States," said Mr. Arnold Bennett, "is the efficiency and fearful universality of the telephone.

To me it was the proudest achievement and the most poetical achievement of the American people."

Lord Northcliffe's experience had a certain dramatic justice which probably even he did not appreciate. He is the proprietor of the *London Times*, a newspaper which, when the telephone was first introduced, denounced it as the "latest American humbug" and declared that it "was far inferior to the well-established system of speaking tubes." The *London Times* delivered this solemn judgment in 1877. A year before, at the Philadelphia Centennial Exposition, Don Pedro, Emperor of Brazil, picked up, almost accidentally, a queer cone-shaped instrument and put it to his ear. "My God! It talks!" was his exclamation; an incident which, when widely published in the press, first informed the American people that another of the greatest inventions of all times had had its birth on their own soil. Yet the initial judgment of the American people did not differ essentially from the opinion which had been more coarsely expressed by the leading English newspaper. Our fathers did not denounce the telephone as an "American humbug," but they did describe it as a curious electric "toy" and ridiculed the notion that

it could ever have any practical value. Even after Alexander Graham Bell and his associates had completely demonstrated its usefulness, the Western Union Telegraph Company refused to purchase all their patent rights for \$100,000! Only forty years have passed since the telephone made such an inauspicious beginning. It remains now, as it was then, essentially an American achievement. Other nations have their telephone systems, but it is only in the United States that its possibilities have been even faintly realized. It is not until Americans visit foreign countries that they understand that, imperfect as in certain directions their industrial and social organization may be, in this respect at least their nation is preëminent.

The United States contains nearly all the telephones in existence, to be exact, about seventy-five per cent. We have about ten million telephones, while Canada, Central America, South America, Great Britain, Europe, Asia, and Africa all combined have only about four million. In order to make an impressive showing, however, we need not include the backward peoples, for a comparison with the most enlightened nations emphasizes the same point. Thus New York City has more telephones than six European countries taken together

— Austria-Hungary, Belgium, Norway, Denmark, Italy, and the Netherlands. Chicago, with a population of 2,000,000, has more telephones than the whole of France, with a population of 40,000,000. Philadelphia, with 1,500,000, has more than the Russian Empire, with 166,000,000. Boston has more telephones than Austria-Hungary, Los Angeles more than the Netherlands, and Kansas City more than Belgium. Several office buildings and hotels in New York City have more instruments than the kingdoms of Greece or Bulgaria. The whole of Great Britain and Ireland has about 650,000 telephones, which is only about 200,000 more than the city of New York.

Mere numbers, however, tell only half the story. It is when we compare service that American superiority stands most manifest. The London newspapers are constantly filled with letters abusing the English telephone system. If these communications describe things accurately, there is apparently no telephone vexation that the Englishman does not have to endure. Delays in getting connections are apparently chronic. At times it seems impossible to get connections at all, especially from four to five in the afternoon — when the operators are taking tea. Suburban

connections, which in New York take about ninety seconds, average half an hour in London, and many of the smaller cities have no night service. An American thinks nothing of putting in a telephone; he notifies his company and in a few days the instrument is installed. We take a thing like this for granted. But there are places where a mere telephone subscription, the privilege of having an instrument installed, is a property right of considerable value and where the telephone service has a "waiting list," like an exclusive club. In Japan one can sell a telephone privilege at a good price, its value being daily quoted on the Stock Exchange. Americans, by constantly using the telephone, have developed what may be called a sixth sense, which enables them to project their personalities over an almost unlimited area. In the United States the telephone has become the one all-prevailing method of communication. The European writes or telegraphs while the American more frequently telephones. In this country the telephone penetrates to places which even the mails never reach. The rural free delivery and other forms of the mail service extend to 58,000 communities, while our 10,000,000 telephones encompass 70,000. We use this instrument for all the

varied experiences of life, domestic, social, and commercial. There are residences in New York City that have private branch exchanges, like a bank or a newspaper office. Hostesses are more and more falling into the habit of telephoning invitations for dinner and other diversions. Many people find telephone conversations more convenient than personal interviews, and it is every day displacing the stenographer and the traveling salesman.

Perhaps the most noteworthy achievement of the telephone is its transformation of country life. In Europe, rural telephones are almost unknown, while in the United States one-third of all our telephone stations are in country districts. The farmer no longer depends upon the mails; like the city man, he telephones. This instrument is thus the greatest civilizing force we have, for civilization is very largely a matter of intercommunication. Indeed, the telephone and other similar agencies, such as the parcel post, the rural free delivery, better roads, and the automobile, are rapidly transforming rural life in this country. In several regions, especially in the Mississippi Valley, a farmer who has no telephone is in a class by himself, like one who has no mowing-machine. Thus the latest returns from Iowa, taken by the census as

far back as 1907, showed that seventy-three per cent of all the farms — 160,000 out of 220,000 — had telephones and the proportion is unquestionably greater now. Every other farmhouse from the Atlantic to the Pacific contains at least one instrument. These statistics clearly show that the telephone has removed half the terrors and isolation of rural life. Many a lonely farmer's wife or daughter, on the approach of a suspicious-looking character, has rushed to the telephone and called up the neighbors, so that now tramps notoriously avoid houses that shelter the protecting wires. In remote sections, insanity, especially among women, is frequently the result of loneliness, a calamity which the telephone is doing much to mitigate.

In the United States today there is one telephone to every nine persons. This achievement represents American invention, genius, industrial organization, and business enterprise at their best. The story of American business contains many chapters and episodes which Americans would willingly forget. But the American Telephone and Telegraph Company represents an industry which has made not a single "swollen fortune," whose largest stockholder is the wife of Alexander Graham Bell, the inventor (a woman who, being totally deaf,

has never talked over the telephone); which has not corrupted legislatures or courts; which has steadily decreased the prices of its products as business and profits have increased; which has never issued watered stock or declared fictitious dividends; and which has always manifested a high sense of responsibility in its dealings with the public.

Two forces, American science and American business capacity, have accomplished this result. As a mechanism, this American telephone system is the product not of one but of many minds. What most strikes the imagination is the story of Alexander Graham Bell, yet other names — Carty, Scribner, Pupin — play a large part in the story.

The man who discovered that an electric current had the power of transmitting sound over a copper wire knew very little about electricity. Had he known more about this agency and less about acoustics, Bell once said himself, he would never have invented the telephone. His father and grandfather had been teachers of the deaf and dumb and had made important researches in acoustics. Alexander Graham Bell, born in Edinburgh in March, 1847, and educated there and in London, followed the ancestral example. This experience

gave Bell an expert knowledge of phonetics that laid the foundation for his life work. His invention, indeed, is clearly associated with his attempts to make the deaf and dumb talk. He was driven to America by ill-health, coming first to Canada, and in 1871 he settled in Boston, where he accepted a position in Boston University to introduce his system of teaching deaf-mutes. He opened a school of "Vocal Physiology," and his success in his chosen field brought him into association with the people who afterward played an important part in the development of the telephone. Not a single element of romance was lacking in Bell's experience; his great invention even involved the love story of his life. Two influential citizens of Boston, Thomas Sanders and Gardiner G. Hubbard, had daughters who were deaf and dumb, and both engaged Bell's services as teacher. Bell lived in Sanders's home for a considerable period, dividing his time between teaching his little pupil how to talk and putting away at a proposed invention which he called a "harmonic telegraph." Both Sanders and Hubbard had become greatly interested in this contrivance and backed Bell financially while he worked. It was Bell's idea that, by a system of tuning different telegraphic receivers

to different pitches, several telegraphic messages could be sent simultaneously over the same wire. The idea was not original with Bell, although he supposed that it was and was entirely unaware that, at the particular moment when he started work, about twenty other inventors were struggling with the same problem. It was one of these other twenty experimenters, Elisha Gray, who ultimately perfected this instrument. Bell's researches have an interest only in that they taught him much about sound transmission and other kindred subjects and so paved the way for his great conception.

One day Hubbard and Sanders learned that Bell had abandoned his "harmonic telegraph" and was experimenting with an entirely new idea. This was the possibility of transmitting the human voice over an electric wire. While working in Sanders's basement, Bell had obtained from a doctor a dead man's ear, and it is said that while he was minutely studying and analyzing this gruesome object, the idea of the telephone first burst upon his mind. For years Bell had been engaged in a task that seemed hopeless to most men — that of making deaf-mutes talk. "If I can make a deaf-mute talk, I can make iron talk," he declared. "If I could make a current of electricity vary in intensity as

the air varies in density," he said at another time, "I could transmit sound telegraphically." Many others, of course, had dreamed of inventing such an instrument. The story of the telephone concerns many men who preceded Bell, one of whom, Philip Reis, produced, in 1861, a mechanism that could send a few discordant sounds, though not the human voice, over an electric wire. Reis seemed to have based his work upon an article published in *The American Journal of Science* by Dr. C. G. Page, of Salem, Mass., in 1837, in which he called attention to the sound given out by an electric magnet when the circuit is opened or closed. The work of these experimenters involves too many technicalities for discussion in this place. The important facts are that they all involved different principles from those worked out by Bell and that none of them ever attained any practical importance. Reis, in particular, never grasped the essential principles that ultimately made the telephone a reality. His work occupies a place in telephone history only because certain financial interests, many years after his death, brought it to light in an attempt to discredit Bell's claim to priority as the inventor. An investigator who seems to have grasped more clearly the basic idea was the distinguished

American inventor Elisha Gray, already mentioned as the man who had succeeded in perfecting the "harmonic telegraph." On February 14, 1876, Gray filed a caveat in the United States Patent Office, setting forth pretty accurately the conception of the electric telephone. The tragedy in Gray's work consists in the fact that, two hours before his caveat had been put in, Bell had filed his application for a patent on the completed instrument.

The champions of Bell and Gray may dispute the question of priority to their heart's content; the historic fact is that the telephone dates from a dramatic moment in the year 1876. Sanders and Hubbard, much annoyed that Bell had abandoned his harmonic telegraph for so visionary an idea as a long distance talking machine, refused to finance him further unless he returned to his original quest. Disappointed and disconsolate, Bell and his assistant, Thomas A. Watson, had started work on the top floor of the Williams Manufacturing Company's shop in Boston. And now another chance happening turned Bell back once more to the telephone. His magnetized telegraph wire stretched from one room to another located in a remote part of the building. One day Watson accidentally plucked a

piece of clock wire that lay near this telegraph wire, and Bell, working in another room, heard the twang. A few seconds later Watson was startled when an excited and somewhat disheveled figure burst into his room. "What was that?" shouted Bell. What had happened was clearly manifest; a sound had been sent distinctly over an electric wire. Bell's harmonic telegraph immediately went into the discard, and the young inventor — Bell was then only twenty-nine — became a man of one passionate idea. Yet final success did not come easily; the inventor worked day and night for forty weeks before he had obtained satisfactory results. It was on March 10, 1876, that Watson, in a distant room, picked up the first telephone receiver and heard these words, the first that had ever passed over a magnetized wire, "Come here, Watson; I want you." The speaking instrument had become a reality, and the foundation of the telephone, in all its present development, had been laid. When the New York and San Francisco line was opened in January, 1915, Alexander Graham Bell spoke these same words to his old associate, Thomas Watson, located in San Francisco, both men using the same instruments that had served so well on that historic occasion forty years before.

Though Bell's first invention comprehended the great basic idea that made it a success, the instrument itself bore few external resemblances to that which has become so commonplace today. If one could transport himself back to this early period and undergo the torture of using this primitive telephone, he would appreciate somewhat the labor, the patience, the inventive skill, and the business organization that have produced the modern telephone. In the first place you would have no separate transmitter and receiver. You would talk into a funnel-shaped contrivance and then place it against your ear to get the returning message. In order to make yourself heard, you would have to shout like a Gloucester sea-captain at the height of a storm. More than the speakers' voices would come over the wire. It seemed to have become the playground of a million devils; moanings, shriekings, mutterings, and noises of all kinds would constantly interrupt the flow of speech. To call up your "party" you would not merely lift the receiver as today; you would tap with a lead pencil, or some other appliance, upon the diaphragm of your transmitter. There were no separate telephone wires. The talking at first was done over the telegraph lines. The earliest "centrals"

reminded most persons of madhouses, for the day of the polite, soft-spoken telephone girl had not arrived. Instead, boys were rushing around with the ends of wires which they were frantically attempting to peg into the holes of the primitive switchboard and so establish "connections." When not knocking down and fighting each other, these boys were swearing into transmitters at the customers; and it is said that the incurable profanity of these early "telephone boys" had much to do with their supersession by girls. In the early days of the telephone, each instrument had to carry its own battery, usually installed in a little box under the transmitter. The early telephone wires, even in the largest cities, were strung on poles, as they are in country and suburban districts today. In places like New York and Chicago, these thousands of overhanging wires not only destroyed the attractiveness of the thoroughfare, but constantly interfered with the fire department and proved to be public nuisances in other ways. A telephone wire, however, loses much of its transmitting power when placed under ground, and it took many years of experimenting before the engineers perfected these subways. In these early days, of course, the telephone was purely a local matter. Certain visionary

enthusiasts had foreseen the possibility of a national, long distance system, but a large amount of labor, both in the laboratory and out, was to be expended before these aspirations could become realities.

The transformation of this rudimentary means of communication into the beautiful mechanism which we have today forms a splendid chapter in the history of American invention. Of all the details in Bell's apparatus the receiver is almost the only one that remains now what it was forty years ago. The story of the transmitter in itself would fill a volume. Edison's success in devising a transmitter which permitted talk in ordinary conversational tones — an invention that became the property of the Western Union Telegraph Company, which early embarked in the telephone business — at one time seemed likely to force the Bell Company out of business. But Emile Berliner and Francis Blake finally came to the rescue with an excellent instrument, and the suggestion of an English clergyman, the Reverend Henry Hummings, that carbon granules be used on the diaphragm, made possible the present perfect instrument. The magneto call bell — still used in certain backward districts — for many years gave fair

results for calling purposes, but the automatic switch, which enables us to get central by merely picking up the receiver, has made possible our great urban service. It was several years before the telephone makers developed so essential a thing as a satisfactory wire. Silver, which gave excellent results, was obviously too costly, and copper, the other metal which had many desirable qualities, was too soft. Thomas B. Doolittle solved this problem by inventing a hard-drawn copper wire. A young man of twenty-two, John J. Carty, suggested a simple device for exorcising the hundreds of "mysterious noises" that had made the use of the telephone so agonizing. It was caused, Carty pointed out, by the circumstance that the telephone, like the telegraph, used a ground circuit for the return wire; the resultant scrapings and moanings and howlings were merely the multitudinous voices of mother earth herself. Mr. Carty began installing the metallic circuit in his lines — that is, he used wire, instead of the ground, to complete the circuit. As a result of this improvement the telephone was immediately cleared of these annoying interruptions. Mr. Carty, who is now Chief Engineer of the American Telephone and Telegraph Company, and the man who has super-

intended all its extensions in recent years, is one of the three or four men who have done most to create the present system. Another is Charles E. Scribner, who, by his invention of that intricate device, the multiple switchboard, has converted the telephone exchange into a smoothly working, orderly place. Scribner's multiple switchboard dates from about 1890. It was Mr. Scribner also who replaced the individual system of dry cells with one common battery located at the central exchange, an improvement which saved the Company 4,000,000 dry cells a year. Then Barrett discovered a method of twisting fifty pairs of wires — since grown to 2400 pairs — into a cable, wrapping them in paper and molding them in lead, and the wires were now taken from poles and placed in conduits underground.

But perhaps the most romantic figure in telephone history, next to Bell, is that of a humble Serbian immigrant who came to this country as a boy and obtained his first employment as a rubber in a Turkish bath. Michael I. Pupin was graduated from Columbia, studied afterward in Germany, and became absorbed in the new subject of electro-mechanics. In particular he became interested in a telephone problem that had bothered the greatest

experts for years. One thing that had prevented the great extension of the telephone, especially for long distance work, was the size of the wire. Long distance lines up to 1900 demanded wire about one-eighth of an inch thick — as thick as a fair-sized lead pencil; and, for this reason, the New York-Chicago line, built in 1893, consumed 870,000 pounds of copper wire of this size. Naturally the enormous expense stood in the way of any extended development. The same thickness also interfered with cable extension. Only about a hundred wires could be squeezed into one cable, against the eighteen hundred now compressed in the same area. Because of these shortcomings, telephone progress, about 1900, was marking time, awaiting the arrival of a thin wire that would do the work of a thick one. The importance of the problem is shown by the fact that one-fourth of all the capital invested in the telephone has been spent in copper. Professor Pupin, who had been a member of the faculty of Columbia University since 1888, solved this problem in his quiet laboratory and, by doing so, won the greatest prize in modern telephone art. His researches resulted in the famous "Pupin coil" by the expedient now known as "loading." When the scientists attempt to explain this invention,

they have to use all kinds of mathematical formulas and curves and, in fact, they usually get to quarreling among themselves over the points involved. What Professor Pupin has apparently done is to free the wire from those miscellaneous disturbances known as "induction." This Pupin invention involved another improvement unsuspected by the inventor, which shows us the telephone in all its mystery and beauty and even its sublimity. Soon after the Pupin coil was introduced, it was discovered that, by crossing the wires of two circuits at regular intervals, another unexplainable circuit was induced. Because this third circuit travels apparently without wires, in some manner which the scientists have not yet discovered, it is appropriately known as the phantom circuit. The practical result is that it is now possible to send three telephone messages and eight telegraph messages over two pairs of wires — all at the same time. Professor Pupin's invention has resulted in economies that amount to millions of dollars, and has made possible long distance lines to practically every part of the United States.

Thus many great inventive minds have produced the physical telephone. We can point to several men — Bell, Blake, Carty, Scribner, Barrett, Pupin

— and say of each one, “Without his work the present telephone system could not exist.” But business genius, as well as mechanical genius, explains this achievement. For the first four or five years of its existence, the new invention had hard sailing. Bell and Thomas Watson, in order to fortify their finances, were forced to travel around the country, giving a kind of vaudeville entertainment. Bell made a speech explaining the new invention, while a cornet player, located in another part of the town, played solos, the music reaching the audience through several telephone instruments placed against the walls. Watson, also located at a distance, varied the program by singing songs via telephone. These lecture tours not only gave Bell the money which he sorely needed but advertised the innovation. There followed a few scattering attempts to introduce the telephone into every-day use and telephone exchanges were established in New York, Boston, Bridgeport, and New Haven. But these pioneers had the hostility of the most powerful corporation of the day — the Western Union Telegraph Company — and they lacked aggressive leaders.

In 1878, Mr. Gardiner Hubbard, Bell’s earliest backer, and now his father-in-law, became

acquainted with a young man who was then serving in Washington as General Superintendent of the Railway Mail Service. This young man was Theodore N. Vail. His energy and enterprise so impressed Hubbard that he immediately asked Vail to become General Manager of the company which he was then forming to exploit the telephone. Viewed from the retrospection of forty years this offer certainly looks like one of the greatest prizes in American business. What it signified at that time, however, is apparent from the fact that the office paid a salary of \$3500 a year and that for the first ten years Vail did not succeed in collecting a dollar of this princely remuneration. Yet it was a happy fortune, not only for the Bell Company but for the nation, that placed Vail at the head of this struggling enterprise. There was a certain appropriateness in his selection, even then. His grand-uncle, Stephen Vail, had built the engines for the first steamship to cross the Atlantic. A cousin had worked with Morse while he was inventing the telegraph. Vail, who was born in Carroll County, Ohio, in 1845, after spending two years as a medical student, suddenly shifted his plans and became a telegraph operator. Then he entered the Railway Mail service; in this service he completely revolutionized

the system and introduced reforms that exist at the present time. A natural bent had apparently directed Vail's mind towards methods of communication, a fact that may perhaps explain the youthful enthusiasm with which he took up the new venture and the vision with which he foresaw and planned its future. For the chief fact about Vail is that he was a business man with an imagination. The crazy little machine which he now undertook to exploit did not interest him as a means of collecting tolls, floating stock, and paying dividends. He saw in it a new method of spreading American civilization and of contributing to the happiness and comfort of millions of people. Indeed Vail had hardly seen the telephone when a picture portraying the development which we are familiar with today unfolded before his eyes. That the telephone has had a greater development in America than elsewhere and that the United States has avoided all those mistakes of organization that have so greatly hampered its growth in other lands, is owing to the fact that Vail, when he first took charge, mapped out the comprehensive policies which have guided his corporation since.

Vail early adopted the "slogan" which has directed the Bell activities for forty years — "One

System! One Policy! Universal Service." In his mind a telephone company was not a city affair, or even a state affair; it was a national affair. His aim has been from the first a universal, national service, all under one head, and reaching every hamlet, every business house, factory, and home in the nation. The idea that any man, anywhere, should be able to take down a receiver and talk to any one, anywhere else in the United States, was the conception which guided Vail's labors from the first. He did not believe that a mass of unrelated companies could give a satisfactory service; if circumstances had ever made a national monopoly, that monopoly was certainly the telephone. Having in view this national, universal, articulating monopoly, Vail insisted on his second great principle, the standardization of equipment. Every man's telephone must be precisely like every other man's, and that must be the best which mechanical skill and inventive genius could produce. To make this a reality and to secure perfect supervision and upkeep, it was necessary that telephones should not be sold but leased. By enforcing these ideas Vail saved the United States from the chaos which exists in certain other countries, such as France, where each subscriber purchases his own instrument,

making his selection from about forty different varieties. That certain dangers were inherent in this universal system Vail understood. Monopoly all too likely brings in excessive charges, poor service, and inside speculation; but it was Vail's plan to justify his system by its works. To this end he established a great engineering department which should study all imaginable mechanical improvements, with the results which have been described. He gave the greatest attention to every detail of the service and particularly insisted on the fairest and most courteous treatment of the public. The "please" which invariably accompanies the telephone girl's request for a number — the familiar "number, please" — is a trifle, but it epitomizes the whole spirit which Vail inspired throughout his entire organization. Though there are plenty of people who think that the existing telephone charges are too high, the fact remains that the rate has steadily declined with the extension of the business. Vail has also kept his company clear from the financial scandals that have disgraced so many other great corporations. He has never received any reward himself except his salary, such fortune as he possesses being the result of personal business ventures in South America

during the twenty years from 1887 to 1907 that he was not associated with the Bell interests.

Vail's first achievement was to rescue this invention from the greatest calamity which would have befallen it. The Western Union Telegraph Company, which in the early days had looked upon the telephone as negligible, suddenly awoke one morning to a realization of its importance. This corporation had recently introduced its "printing telegraph," a device that made it possible to communicate without the intermediary operator. When news reached headquarters that subscribers were dropping this new contrivance and subscribing to telephones, the Western Union first understood that a competitor had entered their field. Promptly organizing the American Speaking Telephone Company, the Western Union, with all its wealth and prestige, proceeded to destroy this insolent pigmy. Its methods of attack were unscrupulous and underhanded, the least discreditable one being the use of its political influence to prevent communities from giving franchises to the Bell Company. But this corporation mainly relied for success upon the wholesale manner in which it infringed the Bell patents. It raked together all possible claimants to priority, from Philip Reis

to Elisha Gray, in its attempts to discredit Bell as the inventor. The Western Union had only one legitimate advantage—the Edison transmitter—which was unquestionably much superior to anything which the Bell Company then possessed. Many Bell stockholders were discouraged in face of this fierce opposition and wished to abandon the fight. Not so Vail. The mere circumstance that the great capitalists of the Western Union had taken up the telephone gave the public a confidence in its value which otherwise it would not have had, a fact which Vail skillfully used in attracting influential financial support. He boldly sued the Western Union in 1878 for infringement of the Bell patents. The case was a famous one; the whole history of the telephone was reviewed from the earliest days, and the evidence as to rival claimants was placed on record for all time. After about a year, Mr. George Gifford, perhaps the best patent attorney of the day, who was conducting the case for the Western Union, quietly informed his clients that they could never win, for the records showed that Bell was the inventor. He advised the Western Union to settle the case out of court and his advice was taken. This great corporation war was concluded by a treaty (November 10, 1879) in

which the Western Union acknowledged that Bell was the inventor, that his patents were valid, and agreed to retire from the telephone business. The Bell Company, on its part, agreed to buy the Western Union Telephone System, to pay the Western Union a royalty of twenty per cent on all telephone rentals, and not to engage in the telegraph business. Had this case been decided against the Bell Company it is almost certain that the telephone would have been smothered in the interest of the telegraph and its development delayed for many years.

Soon after the settlement of the Western Union suit, the original group which had created the telephone withdrew from the scene. Bell went back to teaching deaf-mutes. He has since busied himself with the study of airplanes and wireless, and has invented an instrument for transmitting sound by light. The new telephone company offered him \$10,000 a year as chief inventor, but he replied that he could not invent to order. Thomas Sanders received somewhat less than \$1,000,000 and lost most of it exploiting a Colorado gold mine. Gardiner Hubbard withdrew from business and devoted the last years of his life to the National Geographic Society. Thomas Watson, after retiring from the

telephone business, bought a ship-building yard near Boston, which has been successful.

In making this settlement with the Western Union, the Bell interests not only eliminated a competitor but gained great material advantages. They took over about 56,000 telephone stations located in 55 cities and towns. They also soon acquired the Western Electric Manufacturing Company, which under the control of the Western Union had developed into an important concern for the manufacture of telephone supplies. Under the management of the Bell Company this corporation, which now has extensive factories in Hawthorne, Ill., produces two-thirds of the world's telephone apparatus. With the Western Electric Vail has realized the fundamental conception underlying his ideal telephone system — the standardization of equipment. For the accomplishment of his idea of a national telephone system, instead of a parochial one, Mr. Vail organized, in 1881, the American Bell Telephone Company, a corporation that really represented the federalization of all the telephone activities of the subsidiary companies. The United States was divided into several sections, in each of which a separate company was organized to develop the telephone possibilities of that

particular area. In 1899 the American Telephone and Telegraph Company took over the business and properties of the American Bell Company. The larger corporation built toll lines, connected these smaller systems with one another, and thus made it possible for Washington to talk to New York, New York to Chicago, and ultimately — Boston to San Francisco. An enlightened policy led the Bell Company frequently to establish exchanges in places where there was little chance of immediate profit. Under this stimulation the use of this instrument extended rapidly, yet it is in the last twenty years that the telephone has grown with accelerated momentum. In 1887 there were 170,000 subscribers in the United States, and in 1900 there were 610,000; but in 1906 the American Telephone and Telegraph Company was furnishing its service to 2,550,000 stations, and in 1916 to 10,000,000. Clearly it is only since 1900 that the telephone has become a commonplace of American existence. Up to 1900 it had grown at the rate of about 13,000 a year; whereas since 1900 it has grown at the rate of 700,000 a year. The explanation is that charges have been so reduced that the telephone has been brought within the reach of practically every business house and every family.

Until the year 1900 every telephone subscriber had to pay \$240 a year, and manifestly only families in affluent circumstances could afford such a luxury. About that time a new system of charges known as the "message rate" plan was introduced, according to which the subscriber paid a moderate price for a stipulated number of calls, and a pro rata charge for all calls in excess of that number. Probably no single change in any business has had such an instantaneous effect. The telephone, which had hitherto been an external symbol of prosperity, suddenly became the possession of almost every citizen.

Other companies than the Bell interests have participated in this development. The only time the Bell Company has had no competitor, Mr. Vail has said, was at the Philadelphia Centennial in 1876. Some of this competition has benefited the public but much of it has accomplished little except to enrich many not over-scrupulous promoters. Groups of farmers who frequently started companies to furnish service at cost did much to extend the use of the telephone. Many of the companies which, when the Bell patents expired in 1895, sprang up in the Middle West, also manifested great enterprise and gave excellent service. These

companies have made valuable contributions, of which perhaps the automatic telephone, an instrument which enables a subscriber to call up his "party" directly, without the mediation of "central," is the most ingenious. Although due acknowledgment must be made of the honesty and enterprise with which hundreds of the independents are managed, the fact remains that they are a great economic waste. Most of them give only a local service, no company having yet arisen which aims to duplicate the comprehensive national plans of the greater corporation. As soon as an independent obtains a foothold, the natural consequence is that every business house and private household must either be contented with half service, or double the cost of the telephone by subscribing to two companies. It is not unlikely that the "independents" have exercised a wholesome influence upon the Bell Corporation, but, as the principle of government regulation rather than individual competition has now become the established method of controlling monopoly, this influence will possess less virtue in the future. In addition to these independent enterprises, the telephone has unfortunately furnished an opportunity for stock-jobbing schemes on a considerable scale. The years from

1895 to 1905 witnessed the growth of many bubbles of this kind; one group of men organized not far from two hundred telephone companies. They would go into selected communities, promise a superior service at half the current rates, enlist the coöperation of "leading" business men, sell the stock largely in the city or town to be benefited, make large profits in the construction of the lines and the sale of equipment — and then decamp for pastures new. The multitudinous bankruptcies that followed in the wake of such exploiters at length brought their activities to an end.

CHAPTER V

THE DEVELOPMENT OF PUBLIC UTILITIES

THE streets of practically all American cities, as they appeared in 1870 and as they appear today, present one of the greatest contrasts in our industrial development. Fifty years ago only a few flickering gas lamps lighted the most traveled thoroughfares. Only the most prosperous business houses and homes had even this expensive illumination; most obtained their artificial light from the new illuminant known as kerosene. But it was the mechanism of city transportation that would have looked the strangest in our eyes. New York City had built the world's first horse-car line in 1832, and since that year this peculiarly American contrivance has had the most extended development. In 1870, indeed, practically every city of any importance had one or more railways of this type. New York possessed thirty different companies, each operating an independent system. In Philadelphia,

Chicago, St. Louis, and San Francisco the growth of urban transportation had been equally haphazard. The idea of combining the several street railways into one comprehensive corporation had apparently occurred to no one. The passengers, in their peregrinations through the city, had frequently to pay three or four fares; competition was thus the universal rule. The mechanical equipment similarly represented a primitive state of organization. Horses and mules, in many cases hideous physical specimens of their breeds, furnished the motive power. The cars were little "bobtailed" receptacles, usually badly painted and more often than not in a desperate state of disrepair. In many cities the driver presided as a solitary autocrat; the passengers on entrance deposited their coins in a little fare box. At night tiny oil lamps made the darkness visible; in winter time shivering passengers warmed themselves by pulling their coat collars and furs closely about their necks and thrusting their lower members into a heap of straw, piled almost a foot deep on the floor.

Who would have thought, forty years ago, that the lighting of these dark and dirty streets and the modernization of these local railway systems would have given rise to one of the most astounding

chapters in our financial history and created hundreds, perhaps thousands, of millionaires? When Thomas A. Edison invented the incandescent light, and when Frank J. Sprague in 1887 constructed the first practicable urban trolley line, in Richmond, Virginia, they liberated forces that powerfully affected not only our social and economic life but our political institutions. These two inventions introduced a new phrase — “Public Utilities.” Combined with the great growth and prosperity of the cities they furnished a fruitful opportunity to several particularly famous groups of financial adventurers. They led to the organization of “syndicates” which devoted all their energies, for a quarter of a century, to exploiting city lighting and transportation systems. These syndicates made a business of entering city after city, purchasing the scattered street railway lines and lighting companies, equipping them with electricity, combining them into unified systems, organizing large corporations, and floating huge issues of securities. A single group of six men — Yerkes, Widener, Elkins, Dolan, Whitney, and Ryan — combined the street railways, and in many cases the lighting companies, of New York, Philadelphia, Chicago, Pittsburgh, and at least a hundred towns and cities in Pennsylvania,

Connecticut, Rhode Island, Massachusetts, Ohio, Indiana, New Hampshire, and Maine. Either jointly or separately they controlled the gas and electric lighting companies of Philadelphia, Reading, Harrisburg, Atlanta, Vicksburg, St. Augustine, Minneapolis, Omaha, Des Moines, Kansas City, Sioux City, Syracuse, and about seventy other communities. A single corporation developed nearly all the trolley lines and lighting companies of New Jersey; another controlled similar utilities in San Francisco and other cities on the Pacific Coast. In practically all instances these syndicates adopted precisely the same plan of operation. In so far as their activities resulted in cheap, comfortable, rapid, and comprehensive transit systems and low-priced illumination, their activities greatly benefited the public. The future historian of American society will probably attribute enormous influence to the trolley car in linking urban community with urban community, in extending the radius of the modern city, in freeing urban workers from the demoralizing influences of the tenement, in offering the poorer classes comfortable homes in the surrounding country, and in extending general enlightenment by bringing about a closer human intercourse. Indeed, there is probably no single

influence that has contributed so much to the pleasure and comfort of the masses as the trolley car.

Yet the story that I shall have to tell is not a pleasant one. It is impossible to write even a brief outline of this development without plunging deeply into the two phases of American life of which we have most cause to be ashamed; these are American municipal politics and the speculative aspects of Wall Street. The predominating influences in American city life have been the great franchise corporations. Practically all the men that have had most to do with developing our public utilities have also had the greatest influence in city politics. In New York, Thomas F. Ryan and William C. Whitney were the powerful, though invisible, powers in Tammany Hall. In Chicago, Charles T. Yerkes controlled mayors and city councils; he even extended his influence into the state government, controlling governors and legislatures. In Philadelphia, Widener and Elkins dominated the City Hall and also became part of the Quay machine of Pennsylvania. Mark Hanna, the most active force in Cleveland railways, was also the political boss of the State. Roswell P. Flower, chief agent in developing Brooklyn Rapid Transit, had been Governor of New York; Patrick

Calhoun, who monopolized the utilities of San Francisco and other cities, presided likewise over the city's inner politics. The Public Service Corporation of New Jersey also comprised a large political power in city and state politics. It is hardly an exaggeration to say that in the most active period, that from 1880 to 1905, the powers that developed city railway and lighting companies in American cities were identically the same owners that had the most to do with city government. In the minds of these men politics was necessarily as much a part of their business as trolley poles and steel rails. This type of capitalist existed only on public franchises — the right to occupy the public streets with their trolley cars, gas mains, and electric light conduits; they could obtain these privileges only from complaisant city governments, and the simplest way to obtain them was to control these governments themselves. Herein we have the simple formula which made possible one of the most profitable and one of the most adventurous undertakings of our time.

An attempt to relate the history of all these syndicates would involve endless repetition. If we have the history of one we have the history of practically all. I have therefore selected, as

typical, the operations of the group that developed the street railways and, to a certain extent, the public lighting companies, in our three greatest American cities — New York, Chicago, and Philadelphia.

One of the men who started these enterprises actually had a criminal record. William H. Kemble, an early member of the Philadelphia group, had been indicted for attempting to bribe the Pennsylvania Legislature; he had been convicted and sentenced to one year in the county jail and had escaped imprisonment only by virtue of a pardon obtained through political influence. Charles T. Yerkes, one of his partners in politics and street railway enterprises, had been less fortunate, for he had served seven months for assisting in the embezzlement of Philadelphia funds in 1873. It was this circumstance in Yerkes's career which impelled him to leave Philadelphia and settle in Chicago where, starting as a small broker, he ultimately acquired sufficient resources and influence to embark in that street railway business at which he had already served an extensive apprenticeship. Under his domination, the Chicago aldermen attained a depravity that made them notorious all over the world. They openly sold Yerkes the use of the

streets for cash and constantly blocked the efforts which an infuriated populace made for reform. Yerkes purchased the old street railway lines, lined his pockets by making contracts for their reconstruction, issued large flotations of watered stock, heaped securities upon securities and reorganization upon reorganization and diverted their assets to business in a hundred ingenious ways.

In spite of the crimes which Yerkes perpetrated in American cities, there was something refreshing and ingratiating about the man. Possibly this is because he did not associate any hypocrisy with his depredations. "The secret of success in my business," he once frankly said, "is to buy old junk, fix it up a little, and unload it upon other fellows." Certain of his epigrams — such as, "It is the strap-hanger who pays the dividends" — have likewise given him a genial immortality. The fact that, after having reduced the railway system of Chicago to financial pulp and physical dissolution, he finally unloaded the whole useless mass, at a handsome personal profit, upon his old New York friends, Whitney and Ryan, and decamped to London, where he carried through huge transit enterprises, clearly demonstrated that Yerkes was a buccaneer of no ordinary caliber.

Yerkes's difficulties in Philadelphia indirectly made possible the career of Peter A. B. Widener. For Yerkes had become involved in the defalcation of the City Treasurer, Joseph P. Mercer, whose translation to the Eastern Penitentiary left vacant a municipal office into which Mr. Widener now promptly stepped. Thus Mr. Widener, as is practically the case with all these street railway magnates, was a municipal politician before he became a financier. The fact that he attained the city treasurership shows that he had already gone far, for it was the most powerful office in Philadelphia. He had all those qualities of suavity, joviality, firmness, and personal domination that made possible success in American local politics a generation ago. His occupation contributed to his advancement. In recent years Mr. Widener, as the owner of great art galleries and the patron of philanthropic and industrial institutions, has been a national figure of the utmost dignity. Had you dropped into the Spring Garden Market in Philadelphia forty years ago, you would have found a portly gentleman, clad in a white apron, and armed with a cleaver, presiding over a shop decorated with the design — "Peter A. B. Widener, Butcher." He was constantly joking with his customers and

visitors, and in the evening he was accustomed to foregather with a group of well-chosen spirits who had been long famous in Philadelphia as the "all-night poker players." A successful butcher shop in Philadelphia in those days played about the same part in local politics as did the saloon in New York City. Such a station became the headquarters of political gossip and the meeting ground of a political clique; and so Widener, the son of a poor German bricklayer, rapidly became a political leader in the Twentieth Ward, and soon found his power extending even to Harrisburg. A few years ago Widener presided over a turbulent meeting of Metropolitan shareholders in Newark, New Jersey. The proposal under consideration was the transference of all the Metropolitan's visible assets to a company of which the stockholders knew nothing. When several of these stockholders arose and demanded that they be given an opportunity to discuss the projected lease, Widener turned to them and said, in his politest and blandest manner: "You can vote first and discuss afterward." Widener displayed precisely these same qualities of ingratiating arrogance and good-natured contempt as a Philadelphia politician. He was a man of big frame, alert and decisive in his movements,

and a ready talker; in business he was given much to living in the clouds — a born speculator — emphatically a “boomer.” His sympathies were generous, at times emotional; it is said that he has even been known to weep when discussing his fine collection of Madonnas. He showed this personal side in his lifelong friendship and business association with William L. Elkins, a man much inferior to him in ability. Indeed, Elkins’s great fortune was little more than a free gift from Widener, who carried him as a partner in all his deals. Elkins became Widener’s bondsman when the latter entered the City Treasurer’s office; the two men lived near each other on the same street, and this association was cemented when Widener’s oldest son married Elkins’s daughter. Elkins had started life as an entry clerk in a grocery store, had made money in the butter and egg business, had “struck oil” at Titusville in 1862, and had succeeded in exchanging his holdings for a block of Standard Oil stock. He too became a Philadelphia politician, but he had certain hard qualities — he was close-fisted, slow, plodding — that prevented him from achieving much success.

For the other members of this group we must now change the scene to New York City. In the early

eighties certain powerful interests had formed plans for controlling the New York transit fields. Prominent among them was William Collins Whitney, a very different type of man from the Philadelphians. Born in Conway, Massachusetts, in 1841, he came from a long line of distinguished and intellectual New Englanders. At Yale his wonderful mental gifts raised him far above his fellows; he divided all scholastic honors there with his classmate, William Graham Sumner, afterwards Yale's great political economist. Soon after graduation Whitney came to New York and rapidly forged ahead as a lawyer. Brilliant, polished, suave, he early displayed those qualities which afterward made him the master mind of presidential Cabinets and the maker of American Presidents. Physically handsome, loved by most men and all women, he soon acquired a social standing that amounted almost to a dictatorship. His early political activities had greatly benefited New York. He became a member of that group which, under the leadership of Joseph H. Choate and Samuel J. Tilden, accomplished the downfall of William M. Tweed. Whitney remained Tilden's political protégé for several years. Though high-bred and luxury-loving, as a young man he was not averse to hard political work, and many

old-timers still remember the days when "Bill" Whitney delivered cart-tail harangues on the lower east side. By 1884 he had become the most prominent Democrat in New York — always a foe to Tammany — and as such he contributed largely to Cleveland's first election, became Secretary of the Navy in Cleveland's cabinet and that great President's close friend and adviser. As Secretary of the Navy, Whitney, who found the fleet composed of a few useless hulks left over from the days of Farragut, created the fighting force that did such efficient service in the Spanish War. The fact that the United States is now the third naval power is largely owing to these early activities of Whitney.

Certainly all this national service forms a strange prelude to Whitney's activities in the public utilities of New York and other cities. Had he died, indeed, in his fiftieth year, his name would be renowned today as a worker for the highest ideals of American citizenship. What suddenly made him turn his back upon his past, join his former enemies in Tammany Hall, and engage in these great speculative enterprises? The simplest explanation is that, with his ability and ambition, Whitney had the luxurious tastes of a

Medici. At the height of his career his financial success found expression in a magnificent house which he established on Fifth Avenue. Its furnishings were one of the wonders of New York. Whitney ransacked the art treasures of Europe, stripped medieval castles of their carvings and tapestries, ripped whole staircases and ceilings from the repose of centuries, and relaid them in this abode of splendor, and here he entertained with a lavishness that astounded New York. This single exploit pictures the man. Everything that Whitney did and was — his house, his financial transactions, his Wall Street speculations, the rewards which he gave his friends — assumed heroic proportions. But these things all demanded money. The dilapidated horse railways of New York offered him his most convenient opportunity for amassing it.

But Whitney had not proceeded far when he came face to face with a quiet and energetic young man who had already made considerable progress in the New York transit field. This was a Virginian of South Irish descent who had started life as a humble broker's clerk twelve or fourteen years before. His name was Thomas Fortune Ryan. Few men have wielded greater power in American finance, but in 1884 Ryan was merely a

ruddy-faced, clean-cut, and clean-living Irishman of thirty-three, who could be depended on to execute quickly and faithfully orders on the New York Stock Exchange — even though they were small ones — and who, in unostentatious fashion, had already acquired much influence in Tammany Hall. With his six feet of stature, his extremely slender figure, his long legs, his long arms, his raiment — which always represented the height of fashion and tended slightly toward the flashy — Ryan made a conspicuous figure wherever he went. He was born in 1851, on a small farm in Nelson County, Virginia. The Civil War, which broke out when Ryan was a boy of ten, destroyed the family fortune and in 1868, when seventeen, he began life as a dry-goods clerk in Baltimore, fulfilling the tradition of the successful country boy in the large city by marrying his employer's daughter. When his father-in-law failed, in 1870, Ryan came to New York, went to work in a broker's office, and succeeded so well that, in a few years, he was able to purchase a seat on the Stock Exchange. He was sufficiently skillful as a broker to number Jay Gould among his customers and to inspire a prophecy by William C. Whitney that, if he retained his health, he would become one of the richest men

in the country. Afterwards, when he knew him more intimately, Whitney elaborated this estimate by saying that Ryan was "the most adroit, suave, and noiseless man he had ever known." Ryan had two compelling traits that soon won for him these influential admirers. First of all was his marvelous industry. His genius was not spasmodic. He worked steadily, regularly, never losing a moment, never getting excited, going, day after day, the same monotonous dog-trot, easily outdistancing scores of apparently stronger men. He also had the indispensable faculty of silence. He has always been the least talkative man in Wall Street, but, with all his reserve, he has remained the soul of courtesy and outward good nature.

Here, then, we have the characters of this great impending drama — Yerkes in Chicago, Widener and Elkins in Philadelphia, Whitney and Ryan in New York. These five men did not invariably work as a unit. Yerkes, though he had considerable interest in Philadelphia, which had been the scene of his earliest exploits, limited his activities largely to Chicago. Widener and Elkins, however, not only dominated Philadelphia traction but participated in all of Yerkes's enterprises in Chicago and held an equal interest with Whitney and

Ryan in New York. The latter Metropolitan pair, though they confined their interest chiefly to their own city, at times transferred their attention to Chicago. Thus, for nearly thirty years, these five men found their oyster in the transit systems of America's three greatest cities — and, for that matter, in many others also.

An attempt to trace the convolutions of America's street railway and public lighting finance would involve a puzzling array of statistics and an inextricable complexity of stocks, bonds, leases, holding companies, operating companies, construction companies, reorganizations, and the like. Difficult and apparently impenetrable as is this financial morass, the essential facts still stand out plainly enough. As already indicated, the fundamental basis upon which the whole system rested was the control of municipal politics. The story of the Metropolitan's manipulation of the New York street railways starts with one of the most sordid episodes in the municipal annals of America's largest city. Somewhat more than thirty years ago, a group of New York city fathers acquired an international fame as the "boodle aldermen." These men had finally given way to the importunities of a certain Jacob Sharp, an eccentric

New York character, who had for many years operated New York City railways, and granted a franchise for the construction of a horse-car line on lower Broadway. Soon after voting this franchise, regarded as perhaps the most valuable in the world, these same aldermen had begun to wear diamonds, to purchase real estate, and give other outward evidences of unexpected prosperity. Presently, however, these city fathers started a migration to Canada, Mexico, Spain, and other countries where the processes of extradition did not work smoothly. Sharp's enemies had succeeded in precipitating a legislative investigation under the very capable leadership of Roscoe Conkling, who had little difficulty in showing that Sharp had purchased his aldermen for \$500,000 cash. In a short time, such of the aldermen as were accessible to the police were languishing in prison, and Sharp had been arrested on twenty-one indictments for bribery and sentenced to four years' hard labor — a sentence which he was saved from serving by his lonely and miserable death in Ludlow Street Jail. In the delirium preceding his dissolution Sharp raved constantly about his Broadway railroad and his enemies; it was apparently his belief that the investigation which had

uncovered his rascality and the subsequent "persecutions" had been engineered by certain of his rivals, either to compel Sharp to disgorge his franchise or to produce the facts that would justify the legislature in annulling it on the ground of fraud.

Though the complete history of this transaction can never be written, we do possess certain facts that lend some color to this diagnosis. Up to the time that Sharp had captured this franchise, Ryan, Whitney, and the Philadelphians — not as partners, but as rivals — had competed with him for this prize. At the trial of Arthur J. McQuade in 1886, a fellow conspirator, who bore the somewhat suggestive name of Fullgraff, related certain details which, if true, would indicate that Sharp's methods differed from those of his rivals only in that they had proved more successful. Thirteen members of the Board of Aldermen, said Fullgraff, had formed a close corporation, elected a chairman, and adopted a policy of "business unity in all important matters," which meant that they proposed to keep together in order to secure the highest price for the Broadway franchise. The cable railroad, which was the one with which Mr. Ryan was identified, offered \$750,000, half in bonds and half in cash.

Mr. Sharp, however, offered \$500,000 all in cash. The aldermen voted in favor of Sharp because cash was not only a more valuable commodity than the bonds but, to use Alderman Fullgraff's own words — "less easily traced." That Whitney financed lawsuits against the validity of Sharp's franchise appears upon the record, and that Ryan was actively promoting the Conkling investigation, is likewise a matter of evidence. Sharp's victory had the great result of bringing together the three forces — Ryan, Whitney, and the Philadelphians — who had hitherto combated one another as rivals; that is, it caused the organization of the famous Whitney-Ryan-Widener-Elkins syndicate. If these men had inspired all those attacks on Sharp, their maneuver proved successful; for when the investigation had attained its climax and public indignation against Sharp had reached its most furious stage, that venerable corruptionist, worn down by ill health, and almost crazed by the popular outcry, sold his Broadway railroad to Peter A. B. Widener, William L. Elkins, and William H. Kemble. Thomas F. Ryan became secretary of the new corporation, and William C. Whitney an active participant in its affairs.

This Broadway franchise formed the vertebral

column of the New York transit system; with it as a basis, the operators formed the Metropolitan Street Railway Company in 1893, commonly known as the "Metropolitan." They organized also the Metropolitan Traction Company, an organization which enjoys an historic position as the first "holding company" ever created in this country. Its peculiar attribute was that it did not construct and operate street railways itself, but merely owned other corporations that did so. Its only assets, that is, were paper securities representing the ownership and control of other companies. This "holding company," which has since become almost a standardized form of corporation control in this country, was the invention of Mr. Francis Lynde Stetson, one of America's greatest corporation lawyers. "Mr. Stetson," Ryan is said to have remarked, "do you know what you did when you drew up the papers of the Metropolitan Traction Company? You made us a great big tin box."

The plan which Whitney and his associates now followed was to obtain control, in various ways, of all the surface railways in New York and place them under the leadership of the Metropolitan. Through their political influences they obtained franchises of priceless value, organized subsidiary

street railway companies, and exchanged the stock of these subsidiary companies for that of the Metropolitan. A few illustrations will show the character of these transactions. They thus acquired, practically as a free gift, a franchise to build a cable railroad on Lexington Avenue. At an extremely liberal estimate, this line cost perhaps \$2,500,000 to construct, yet the syndicate turned this over to the Metropolitan for \$10,000,000 of Metropolitan securities. They similarly acquired a franchise for a line on Columbus Avenue, spending perhaps \$500,000 in construction, and handing the completed property over to the Metropolitan for \$6,000,000. In exchange for these two properties, representing a real investment, it has been maintained, of \$3,000,000, the inside syndicates received securities which had a face value of \$16,000,000 and which, as will appear subsequently, had a market cash value of not far from \$25,000,000. They purchased an old horse-car line on Fulton Street, a line whose assets consisted of one-third of a mile of tracks, ten little box cars, thirty horses, and an operating deficit of \$40,000 a year. At auction, its visible assets might have brought \$15,000; yet the syndicate turned this over to the Metropolitan for \$1,000,000. They spent \$50,000

in constructing and equipping a horse railroad on Twenty-eighth and Twenty-ninth Streets and turned this over to the Metropolitan for \$3,000,000. For two and a half miles of railroad on Thirty-fourth Street, which represented a cash expenditure of perhaps \$100,000, they received \$2,000,000 of Metropolitan stock. But it is hardly necessary to catalogue more instances; the plan of operations must now be fairly evident. It was for the members of the syndicate, as individuals, to collect all the properties and new franchises that were available and to transfer them to the Metropolitan at enormously inflated values. So far, all these deals were purely stock transactions — no cash had yet changed hands. When the amalgamation was complete, the insiders found themselves in possession of large amounts of Metropolitan stock. Their scheme for transforming this paper into more tangible property forms the concluding chapter of this Metropolitan story.¹

Nearly all the properties actually purchased and transferred in the manner described above, had little earning capacity, and therefore little value; they were decrepit horse-car lines in unprofitable

¹ In 1897 the Traction Company dissolved, after distributing \$6,000,000 as "a voluntary dividend" among its stockholders.

territory. The really valuable roads were those that traversed the great north and south thoroughfares — Lenox, Third, Fourth, Sixth, Eighth, and Ninth Avenues. Many old New York families and estates had held these properties for years and had collected large annual dividends from them. Naturally they had no desire to sell, yet their acquisition was essential to the monopoly which the Whitney-Ryan syndicate aspired to construct. They finally leased all these roads, under agreements which guaranteed large annual rentals. In practically all these cases the Metropolitan, in order to secure physical possession, agreed to pay rentals that far exceeded the earning capacity of the road. What is the explanation of such insane finance? We do not have the precise facts in the matter of the New York railways; but similar operations in Chicago, which have been officially made public, shed the utmost light upon the situation. In order to get possession of a single road in Chicago, Widener and Elkins guaranteed a thirty-five per cent dividend; to get one Philadelphia line, they guaranteed $65\frac{1}{2}$ per cent on capital paid in. This, of course, was not business; the motives actuating the syndicate were purely speculative. In Chicago, Widener and Elkins quietly made large purchases

of the stock in these roads before they leased them to the parent company. The exceedingly profitable lease naturally gave such stocks a high value, in case they preferred to sell; if they held them, they reaped huge rewards from the leases which they had themselves decreed. Perhaps their most remarkable exploit was the lease of the West Division Railway Company of Chicago to the West Chicago Street Railroad. Widener and Elkins controlled the West Division Railway; their partner, Charles T. Yerkes, controlled the latter corporation. The negotiation of a lease, therefore, was a purely informal matter; the partners were merely dealing with one another; yet Widener and Elkins received a fee of \$5,000,000 as personal compensation for negotiating this lease!

But this whole leasing system, both in New York and Chicago, entailed scandals perhaps even more reprehensible. All these leased properties, when taken over, were horse-car lines, and their transformation into electrically propelled systems involved reconstruction operations on an extensive scale. It seems perfectly clear that the chief motive which inspired these extravagant leases was the determination of the individuals who made up the syndicate to obtain physical possession and

to make huge profits on construction. The "construction accounts" of the Metropolitan in New York form the most mysterious and incredible chapter in its history. The Metropolitan reports show that they spent anywhere from \$500,000 to \$600,000 a mile building underground trolley lines which, at their own extravagant estimate, should have cost only \$150,000. In a few years untold millions, wasted in this way, disappeared from the Metropolitan treasury. In 1907 the Public Service Commission of New York began investigating these "construction accounts," but it had not proceeded far when the discovery was made that all the Metropolitan books containing the information desired had been destroyed. All the ledgers, journals, checks, and vouchers containing the financial history of the Metropolitan since its organization in 1893 had been sold for \$117 to a junkman, who had agreed in writing to grind them into pulp, so that they would be safe from "prying eyes." We shall therefore never know precisely how this money was spent. But here again the Chicago transactions help us to an understanding. In 1898 Charles T. Yerkes, with that cynical frankness which some people have regarded as a redeeming trait in his character, opened his books for the

preceding twenty-five years to the Civic Federation of Chicago. These books disclosed that Mr. Yerkes and his associates, Widener and Elkins, had made many millions in reconstructing the Chicago lines at prices which represented gross overcharges to the stockholders. For this purpose Yerkes, Widener, and Elkins organized the United States Construction Company and made contracts for installing the new electric systems on the lines which they controlled by lease or stock ownership. It seems a not unnatural suspicion that the vanished Metropolitan books would have disclosed similar performances in New York.

The concluding chapter of this tragedy has its setting in the Stock Exchange. These inside gentlemen, as already said, received no cash as their profits from these manipulations—only stock. But in the eyes of the public this stock represented an enormous value. Metropolitan securities, for example, represented the control and ownership of all the surface transit business in the city of New York. Naturally, it had a great investment value. When it began to pay regularly seven per cent dividends, the public appetite for Metropolitan became insatiable. The eager purchasers did not know, what we know now, that the Metropolitan did not

earn these dividends and never could have earned them. The mere fact that it was paying, as rentals on its leased lines, annual sums far in excess of their earning capacity, necessarily prevented anything in the nature of profitable operation. The unpleasant fact is that these dividends were paid with borrowed money merely to make the stock marketable. It is not unlikely that the padded construction accounts, already described, may have concealed large disbursements of money for unearned dividends. When the Metropolitan was listed in 1897, it immediately went beyond par. The excitement that followed forms one of the most memorable chapters in the history of Wall Street. The investing public, egged on by daring and skillful stock manipulators, simply went mad and purchased not only Metropolitan but street railway shares that were then even more speculative. It was in these bubble days that Brooklyn Rapid Transit soared to heights from which it subsequently descended precipitately. Under this stimulus, Metropolitan stock ultimately sold at \$269 a share. While the whole investing public was scrambling for Metropolitan, the members of the exploiting syndicate found ample opportunity to sell. The real situation became apparent when William

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C. Whitney died in 1904 leaving an estate valued at \$40,000,000. Not a single share of Metropolitan was found among his assets! The final crash came in 1907, when the Metropolitan, a wrecked and plundered shell, confessed insolvency and went into a receivership. Those who had purchased its stock found their holdings as worthless as the traditional western gold mine. The story of the Chicago and Philadelphia systems, as well as that of numerous other cities, had been essentially the same. The transit facilities of millions of Americans had merely become the instruments of a group of speculators who had made huge personal fortunes and had left, as a monument of their labors, street railway lines whose gross overcapitalization was apparent to all and whose physical dilapidation in many cases revealed the character of their management.

It seems perhaps an exaggeration to say that the enterprises which have resulted in equipping our American cities and suburbs with trolley lines and electric lighting facilities have followed the plan of campaign sketched above. Perhaps not all have repeated the worst excesses of the syndicate that so remorselessly exploited New York, Chicago, and Philadelphia. Yet in most cases these elaborate undertakings have been largely speculative in

character. Huge issues of fictitious stock, created purely for the benefit of inner rings, have been almost the prevailing rule. Stock speculation and municipal corruption have constantly gone hand in hand everywhere with the development of the public utilities. The relation of franchise corporations to municipalities is probably the thing which has chiefly opened the eyes of Americans to certain glaring defects in their democratic organization. The popular agitation which has resulted has led to great political reforms. The one satisfaction which we can derive from such a relation as that given above is that, after all, it is representative of a past era in our political and economic life. No new "Metropolitan syndicate" can ever repeat the operations of its predecessors. Practically every State now has utility commissions which regulate the granting of franchises, the issue of securities, the details of construction and equipment and service. An awakened public conscience has effectively ended the alliance between politics and franchise corporations and the type of syndicate described in the foregoing pages belongs as much to our American past as that rude frontier civilization with which, after all, it had many characteristics in common.

CHAPTER VI

MAKING THE WORLD'S AGRICULTURAL MACHINERY

THE Civil War in America did more than free the negro slave: it freed the white man as well. In the Civil War agriculture, for the first time in history, ceased to be exclusively a manual art. Up to that time the typical agricultural laborer had been a bent figure, tending his fields and garnering his crops with his own hands. Before the war had ended the American farmer had assumed an erect position; the sickle and the scythe had given way to a strange red chariot, which, with practically no expenditure of human labor, easily did the work of a dozen men. Many as have been America's contributions to civilization, hardly any have exerted greater influence in promoting human welfare than her gift of agricultural machinery. It seems astounding that, until McCormick invented his reaper, in 1831, agricultural methods, in both the New and the Old World, differed little from those

that had prevailed in the days of the Babylonians. The New England farmer sowed his fields and reaped his crops with almost identically the same instruments as those which had been used by the Roman farmer in the time of the Gracchi. Only a comparatively few used the scythe; the great majority, with crooked backs and bended knees, cut the grain with little hand sickles precisely like those which are now dug up in Etruscan and Egyptian tombs.

Though McCormick had invented his reaper in 1831, and though many rival machines had appeared in the twenty years preceding the Civil War, only the farmers on the great western plains had used the new machinery to any considerable extent. The agricultural papers and agricultural fairs had not succeeded in popularizing these great labor-saving devices. Labor was so abundant and so cheap that the farmer had no need of them. But the Civil War took one man in three for the armies, and it was under this pressure that the farmers really discovered the value of machinery. A small boy or girl could mount a McCormick reaper and cut a dozen acres of grain in a day. This circumstance made it possible to place millions of soldiers in the field and to feed the armies from farms on

which mature men did very little work. But the reaper promoted the Northern cause in other ways. Its use extended so in the early years of the war that the products of the farms increased on an enormous scale, and the surplus, exported to Europe, furnished the liquid capital that made possible the financing of the war. Europe gazed in astonishment at a new spectacle in history; that of a nation fighting the greatest war which had been known up to that time, employing the greater part of her young and vigorous men in the armies, and yet growing infinitely richer in the process. The Civil War produced many new implements of warfare, such as the machine gun and the revolving turret for battleships, but, so far as determining the result was concerned, perhaps the most important was the reaper.

Extensive as the use of agricultural machinery became in the Civil War, that period only faintly foreshadowed the development that has taken place since. The American farm is today like a huge factory; the use of the hands has almost entirely disappeared; there are only a few operations of husbandry that are not performed automatically. In Civil War days the reaper merely cut the grain; now machinery rakes it up and binds it into sheaves

and threshes it. Similar mechanisms bind corn and rice. Machinery is now used to plant potatoes; grain, cotton, and other farm products are sown automatically. The husking bees that formed one of our social diversions in Civil War days have disappeared, for particular machines now rip the husks off the ears. Horse hay-forks and horse hay-rakes have supplanted manual labor. The mere names of scores of modern instruments of farming, all unknown in Civil War days — hay carriers, hay loaders, hay stackers, manure spreaders, horse corn planters, corn drills, disk harrows, disk ploughs, steam ploughs, tractors, and the like — give some suggestion of the extent to which America has made mechanical the most ancient of occupations. In thus transforming agriculture, we have developed not only our own Western plains, but we have created new countries. Argentina could hardly exist today except for American agricultural machinery. Ex-President Loubet declared, a few years ago, that France would starve to death except for the farming machines that were turned out in Chicago. There is practically no part of the world where our self-binders are not used. In many places America is not known as the land of freedom and opportunity, but merely as “the place

from which the reapers come." The traveler suddenly comes upon these familiar agents in every European country, in South America, in Egypt, China, Algiers, Siberia, India, Burma, and Australia. For agricultural machinery remains today, what it has always been, almost exclusively an American manufacture. It is practically the only native American product that our European competitors have not been able to imitate. Tariff walls, bounty systems, and all the other artificial aids to manufacturing have not developed this industry in foreign lands, and today the United States produces four-fifths of all the agricultural machinery used in the world. The International Harvester Company has its salesmen in more than fifty countries, and has established large American factories in many nations of Europe.

One day, a few years before his death, Prince Bismarck was driving on his estate, closely following a self-binder that had recently been put to work. The venerable statesman, bent and feeble, seemed to find a deep melancholy interest in the operation.

"Show me the thing that ties the knot," he said. It was taken to pieces and explained to him in detail.

“Can these machines be made in Germany?” he asked.

“No, your Excellency,” came the reply. “They can be made only in America.”

The old man gave a sigh. “Those Yankees are ingenious fellows,” he said. “This is a wonderful machine.”

In this story of American success, four names stand out preëminently. The men who made the greatest contributions were Cyrus H. McCormick, C. W. Marsh, Charles B. Withington, and John F. Appleby. The name that stands foremost, of course, is that of McCormick, but each of the others made additions to his invention that have produced the present finished machine. It seems like the stroke of an ironical fate which decreed that since it was the invention of a Northerner, Eli Whitney, that made inevitable the Civil War, so it was the invention of a Southerner, Cyrus McCormick, that made inevitable the ending of that war in favor of the North.

McCormick was born in Rockbridge County, Virginia, on a farm about eighteen miles from Staunton. He was a child of that pioneering Scotch-Irish race which contributed so greatly to the settlement of this region and which afterward

made such inestimable additions to American citizenship. The country in which he grew up was rough and, so far as the conventionalities go, uncivilized; the family homestead was little more than a log cabin; and existence meant a continual struggle with a not particularly fruitful soil. The most remarkable figure in the McCormick home circle, and the one whose every-day life exerted the greatest influence on the boy, was his father. The older McCormick had one obsessing idea that made him the favorite butt of the local humorists. He believed that the labor spent in reaping grain was a useless expenditure of human effort and that machinery might be made to do the work. Other men, in this country and in Europe, had nourished similar notions. Several Englishmen had invented reaping machines, all of which had had only a single defect — they would not reap. An ingenious English actor had developed a contrivance which would cut imitation wheat on the stage, but no one had developed a machine that would work satisfactorily in real life. Robert McCormick spent the larger part of his days and nights tinkering at a practical machine. He finally produced a horrific contrivance, made up of whirling sickles, knives, and revolving rods, pushed from behind by two

horses; when he tried this upon a grain-field, however, it made a humiliating failure.

Evidently Robert McCormick had ambitions far beyond his powers; yet without his absurd experiments the development of American agriculture might have waited many years. They became the favorite topics of conversation in the evening gatherings that took place about the family log fire. Robert McCormick had several sons, and one manifested a particular interest in his repeated failures. From the time he was seven years old Cyrus Hall McCormick became his father's closest companion. Others might ridicule and revile, but this chubby, bright-eyed, intelligent little boy was always the keenest listener, the one comfort which the father had against his jeering neighbors. He also became his father's constant associate in his rough workshop. Soon, however, the older man noticed a change in their relations. The boy was becoming the teacher, and the father was taught. By the time Cyrus was eighteen, indeed, he had advanced so far beyond his father that the latter had become merely a proud observer. Young McCormick threw into the discard all his father's ideas and struck out on entirely new lines. By the time he had reached his twenty-second birthday he

had constructed a machine which, in all its essential details, is the one which we have today. He had introduced seven principles, all of which are an indispensable part of every reaper constructed now. One afternoon he drove his unlovely contraption upon his father's farm, with no witnesses except his own family. This group now witnessed the first successful attempt ever made to reap with machinery. A few days later young McCormick gave a public exhibition at Steele's Tavern, cutting six acres of oats in an afternoon. The popular ridicule soon changed into acclaim; the new invention was exhibited in a public square and Cyrus McCormick became a local celebrity. Perhaps the words that pleased him most, however, were those spoken by his father. "I am proud," said the old man, "to have a son who can do what I failed to do."

This McCormick reaper dates from 1831; but it represented merely the beginnings of the modern machine. It performed only a single function; it simply cut the crop. When its sliding blade had performed this task, the grain fell back upon a platform, and a farm hand, walking alongside, raked this off upon the ground. A number of human harvesters followed, picked up the bundles, and tied a

few strips of grain around them, making the sheaf. The work was exceedingly wearying and particularly hard upon the women who were frequently impressed into service as farm-hands. About 1858 two farmers named Marsh, who lived near De Kalb, Illinois, solved this problem. They attached to their McCormick reaper a moving platform upon which the cut grain was deposited. A footboard was fixed to the machine upon which two men stood. As the grain came upon this moving platform these men seized it, bound it into sheaves, and threw it upon the field. Simple as this procedure seemed it really worked a revolution in agriculture; for the first time since the pronouncement of the primal curse, the farmer abandoned his hunchback attitude and did his work standing erect. Yet this device also had its disqualifications, the chief one being that it converted the human sheaf-binder into a sweat-shop worker. It was necessary to bind the grain as rapidly as the platform brought it up; the worker was therefore kept in constant motion; and the consequences were frequently distressing and nerve racking. Yet this "Marsh Harvester" remained the great favorite with farmers from about 1860 to 1874.

All this time, however, there was a growing

feeling that even the Marsh harvester did not represent the final solution of the problem; the air was full of talk and prophecies about self-binders, something that would take the loose wheat from the platform and transform it into sheaves. Hundreds of attempts failed until, in 1874, Charles B. Withington of Janesville, Wisconsin, brought to McCormick a mechanism composed of two steel arms which seized the grain, twisted a wire around it, cut the wire, and tossed the completed sheaf to the earth. In actual practice this contrivance worked with the utmost precision. Finally American farmers had a machine that cut the grain, raked it up, and bound it into sheaves ready for the mill. Human labor had apparently lost its usefulness; a solitary man or woman, perched upon a seat and driving a pair of horses, now performed all these operations of husbandry.

By this time, scores of manufacturers had entered the field in opposition to McCormick, but his acquisition of Withington's invention had apparently made his position secure. Indeed, for the next ten years he had everything his own way. Then suddenly an ex-keeper of a dry-goods store in Maine crossed his path. This was William Deering, a character quite as energetic, forceful, and

pugnacious as was McCormick himself. Though McCormick had made and sold thousands of his self-binders, farmers were already showing signs of discontent. The wire proved a continual annoyance. It mingled with the straw and killed the cattle — at least so the farmers complained; it cut their hands and even found its way, with disastrous results, into the flour mills. Deering now appeared as the owner of a startling invention by John F. Appleby. This did all that the Withington machine did and did it better and quicker; and it had the great advantage that it bound with twine instead of wire. The new machine immediately swept aside all competitors; McCormick, to save his reaper from disaster, presently perfected a twine binder of his own. The appearance of Appleby's improvement in 1884 completes the cycle of the McCormick reaper on its mechanical side. The harvesting machine of fifty nations to-day is the one to which Appleby put the final touches in 1884. Since then nothing of any great importance has been added.

This outline of invention, however, comprises only part of the story. The development of the reaper business presents a narrative quite as adventurous as that of the reaper itself. Cyrus

McCormick was not only a great inventor; he was also a great business man. So great was his ability in this direction, indeed, that there has been a tendency to discredit his achievements as a creative genius and to attribute his success to his talents as an organizer and driver of industry. "I may make a million dollars from this reaper," said McCormick, in the full tide of enthusiasm over his invention; and these words indicate an indispensable part of his program. He had no miserly instinct but he had one overpowering ambition. It was McCormick's conviction, almost religious in its fervor, that the harvester business of the world belonged to him. As already indicated, plenty of other hardy spirits, many of them almost as commanding personalities as himself, disputed the empire. Not far from 12,000 patents on harvesting machines were granted in this country in the fifty years following McCormick's invention, and more than two hundred companies were formed to compete for the market. McCormick always regarded these competitors as highwaymen who had invaded a field which had been almost divinely set apart for himself. A man of covenanting antecedents, heroic in his physical proportions, with a massive, Jove-like head and beard, tirelessly devoted to his work,

watching every detail with a microscopic eye, marshaling a huge force of workers who were as possessed by this one overruling idea as was McCormick himself, he certainly presented an almost unassailable battlefield to his antagonists.

The competition that raged between McCormick and the makers of rival machines was probably the fiercest that has prevailed in any American industry. For marketing his machine McCormick developed a system almost as ingenious as the machine itself. The popularization of so ungainly and expensive a contrivance as the harvester proved a slow and difficult task. McCormick at first attempted to build his product on his Virginia farm and for many years it was known as the Virginia Reaper. Nearly ten years passed, however, before he sold his first machine. The farmer first refused to take it seriously. "It's a great invention," he would say, "but I'm running a farm, not a circus." About 1847 McCormick decided that the Western prairies offered the finest field for its activities, and established his factory at Chicago, then an ugly little town on the borders of a swamp. This selection proved to be a stroke of genius, for it placed the harvesting factory right at the door of its largest market.

The price of the harvester, however, seemed an insurmountable obstacle to its extensive use. The early settlers of the Western plains had little more than their brawny hands as capital, and the homestead law furnished them their land practically free. In the eyes of a large-seeing pioneer like McCormick this was capital enough. He determined that his reaper should develop this extensive domain, and that the crops themselves should pay the cost. Selling expensive articles on the installment plan now seems a commonplace of business, but in those days it was practically unknown. McCormick was the first to see its possibilities. He established an agent, usually the general storekeeper, in every agricultural center. Any farmer who had a modicum of cash and who bore a reputation for thrift and honesty could purchase a reaper. In payment he gave a series of notes, so timed that they fell due at the end of harvesting seasons. Thus, as the money came in from successive harvests, the pioneer paid off the notes, taking two, three, or four years in the process. In the sixties and seventies immigrants from the Eastern States and from Europe poured into the Mississippi Valley by the hundreds of thousands. Almost the first person who greeted

the astonished Dane, German, or Swede was an agent of the harvester company, offering to let him have one of these strange machines on these terms. Thus the harvester, under McCormick's comprehensive selling plans, did as much as the homestead act in opening up this great farming region.

McCormick covered the whole agricultural United States with these agents. In this his numerous competitors followed suit, and the liveliest times ensued. From that day to this the agents of harvesting implements have lent much animation and color to rural life in this country. Half a dozen men were usually tugging away at one farmer at the same time. The mere fact that the farmer had closed a contract did not end his troubles, for "busting up competitors' sales" was part of the agent's business. The situation frequently reached a point where there was only one way to settle rival claims and that was by a field contest. At a stated time two or three or four rival harvesters would suddenly appear on the farmer's soil, each prepared to show, by actual test, its superiority over the enemy. Farmers and idlers for miles around would gather to witness the Homeric struggle. At a given signal the small army of machines would spring savagely at a field

of wheat. The one that could cut the allotted area in the shortest time was regarded as the winner. The harvester would rush on all kinds of fields, flat and hilly, dry and wet, and would cut all kinds of crops, and even stubble. All manner of tests were devised to prove one machine stronger than its rival; a favorite idea was to chain two back to back, and have them pulled apart by frantic careering horses; the one that suffered the fewest breakdowns would be generally acclaimed from town to town. Sometimes these field tests were the most exciting and spectacular events at country fairs.

Thus the harvesting machine "pushed the frontier westward at the rate of thirty miles a year," according to William H. Seward. It made American and Canadian agriculture the most efficient in the world. The German brags that his agriculture is superior to American, quoting as proof the more bushels of wheat or potatoes he grows to an acre. But the comparison is fallacious. The real test of efficiency is, not the crops that are grown per acre, but the crops that are grown per man employed. German efficiency gets its results by impressing women as cultivators — depressing bent figures that are in themselves a sufficient criticism upon any civilization. America gets its results

by using a minimum of human labor and letting machinery do the work. Thus America's methods are superior not only from the standpoint of economics but of social progress. All nations, including Germany, use our machinery, but none to the extent that prevails on the North American Continent.

Perhaps McCormick's greatest achievement is that his machine has banished famine wherever it is extensively used, at least in peace times. Before the reaper appeared existence, even in the United States, was primarily a primitive struggle for bread. The greatest service of the harvester has been that it has freed the world—unless it is a world distracted by disintegrating war—from a constant anxiety concerning its food supply. The hundreds of thousands of binders, active in the fields of every country, have made it certain that humankind shall not want for its daily bread. When McCormick exhibited his harvester at the London Exposition of 1851, the *London Times* ridiculed it as “a cross between an Astley chariot, a wheel barrow, and a flying machine.” Yet this same grotesque object, widely used in Canada, Argentina, Australia, South Africa, and India, becomes an engine that really holds the British Empire together.

For the forty years succeeding the Civil War the manufacture of harvesting machinery was a business in which many engaged, but in which few survived. The wildest competition ruthlessly destroyed all but half a dozen powerful firms. Cyrus McCormick died in 1884, but his sons proved worthy successors; the McCormick factory still headed the list, manufacturing, in 1900, one-third of all the self-binders used in the world. The William Deering Company came next and then D. M. Osborne, J. J. Glessner, and W. H. Jones, established factories that made existence exceedingly uncomfortable for the pioneers. Whatever one may think of the motives which caused so many combinations in the early years of the twentieth century, there is no question that irresistible economic forces compelled these great harvester companies to get together. Quick profits in the shape of watered stock had nothing to do with the formation of the International Harvester Company. All the men who controlled these enterprises were individualists, with a natural loathing for trusts, combinations, and pools. They wished for nothing better than to continue fighting the Spartan battle that had made existence such an exciting pastime for more than half a century. But the simple fact

was that these several concerns were destroying one another; it was a question of joining hands, ending the competition that was eating so deeply into their financial resources, or reducing the whole business to chaos. When Mr. George W. Perkins, of J. P. Morgan and Company, first attempted to combine these great companies, the antagonisms which had been accumulated in many years of warfare constantly threatened to defeat his end. He early discovered that the only way to bring these men together was to keep them apart. The usual way of creating such combinations is to collect the representative leaders, place them around a table, and persuade them to talk the thing over. Such an amicable situation, however, was impossible in the present instance. Even when the four big men — McCormick, Deering, Glessner, and Jones — were finally brought for the final treaty of peace to J. P. Morgan's office, Mr. Perkins had to station them in four separate rooms and flit from one to another arranging terms. Had these four men been brought face to face, the Harvester Company would probably never have been formed.

Having once signed their names, however, these once antagonistic interests had little difficulty in forming a strong combination. The company thus

brought together manufactured 85 per cent of all the farm machinery used in this country. It owned its own coal-fields and iron mines and its own forests, and it produces most of the implements used by 10,000,000 farmers. In 1847 Cyrus McCormick made 100 reapers and sold them for \$10,000; by 1902 the annual production of the corporation amounted to hundreds of thousands of harvesters — besides an almost endless assortment of other agricultural tools, ploughs, drills, rakes, gasoline engines, tractors, threshers, cream separators, and the like — and the sales had grown to about \$75,000,000. This is merely the financial measure of progress; the genuine achievements of McCormick's invention are millions of acres of productive land and a farming population which is without parallel elsewhere for its prosperity, intelligence, manfulness, and general contentment.

CHAPTER VII

THE DEMOCRATIZATION OF THE AUTOMOBILE

IN many manufacturing lines, American genius for organization and large scale production has developed mammoth industries. In nearly all the tendency to combination and concentration has exercised a predominating influence. In the early years of the twentieth century the public realized, for the first time, that one corporation, the American Sugar Refining Company, controlled ninety-eight per cent of the business of refining sugar. Six large interests — Armour, Swift, Morris, the National Packing Company, Cudahy, and Schwarzschild and Sulzberger — had so concentrated the packing business that, by 1905, they slaughtered practically all the cattle shipped to Western centers and furnished most of the beef consumed in the large cities east of Pittsburgh. The "Tobacco Trust" had largely monopolized both the wholesale and retail trade in this article of luxury and had also made

extensive inroads into the English market. The textile industry had not only transformed great centers of New England into an American Lancashire, but the Southern States, recovering from the demoralization of the Civil War, had begun to spin their own cotton and to send the finished product to all parts of the world. American shoe manufacturers had developed their art to a point where "American shoes" had acquired a distinctive standing in practically every European country.

It is hardly necessary to describe in detail each of these industries. In their broad outlines they merely repeat the story of steel, of oil, of agricultural machinery; they are the product of the same methods, the same initiative. There is one branch of American manufacture, however, that merits more detailed attention. If we scan the manufacturing statistics of 1917, one amazing fact stares us in the face. There are only three American industries whose product has attained the billion mark; one of these is steel, the other food products, while the third is an industry that was practically unknown in the United States fifteen years ago. Superlatives come naturally to mind in discussing American progress, but hardly any extravagant phrases could do justice to the development of

American automobiles. In 1899 the United States produced 3700 motor vehicles; in 1916 we made 1,500,000. The man who now makes a personal profit of not far from \$50,000,000 a year in this industry was a puttering mechanic when the twentieth century came in. If we capitalized Henry Ford's income, he is probably a richer man than Rockefeller; yet, as recently as 1905 his possessions consisted of a little shed of a factory which employed a dozen workmen. Dazzling as is this personal success, its really important aspects are the things for which it stands. The American automobile has had its wild-cat days; for the larger part, however, its leaders have paid little attention to Wall Street, but have limited their activities exclusively to manufacturing. Moreover, the automobile illustrates more completely than any other industry the technical qualities that so largely explain our industrial progress. Above all, American manufacturing has developed three characteristics. These are quantity production, standardization, and the use of labor-saving machinery. It is because Ford and other manufacturers adapted these principles to making the automobile that the American motor industry has reached such gigantic proportions.

A few years ago an English manufacturer, seeking the explanation of America's ability to produce an excellent car so cheaply, made an interesting experiment. He obtained three American automobiles, all of the same "standardized" make, and gave them a long and racking tour over English highways. Workmen then took apart the three cars and threw the disjointed remains into a promiscuous heap. Every bolt, bar, gas tank, motor, wheel, and tire was taken from its accustomed place and piled up, a hideous mass of rubbish. Workmen then painstakingly put together three cars from these disordered elements. Three chauffeurs jumped on these cars, and they immediately started down the road and made a long journey just as acceptably as before. The Englishman had learned the secret of American success with automobiles. The one word "standardization" explained the mystery.

Yet when, a few years before, the English referred to the American automobile as a "glorified perambulator," the characterization was not unjust. This new method of transportation was slow in finding favor on our side of the Atlantic. America was sentimentally and practically devoted to the horse as the motive power for vehicles; and the

fact that we had so few good roads also worked against the introduction of the automobile. Yet here, as in Europe, the mechanically propelled wagon made its appearance in early times. This vehicle, like the bicycle, is not essentially a modern invention; the reason any one can manufacture it is that practically all the basic ideas antedate 1840. Indeed, the automobile is really older than the railroad. In the twenties and thirties, steam stage coaches made regular trips between certain cities in England and occasionally a much resounding power-driven carriage would come careering through New York and Philadelphia, scaring all the horses and precipitating the intervention of the authorities. The hardy spirits who devised these engines, all of whose names are recorded in the encyclopedias, deservedly rank as the "fathers" of the automobile. The responsibility as the actual "inventor" can probably be no more definitely placed. However, had it not been for two developments, neither of them immediately related to the motor car, we should never have had this efficient method of transportation. The real "fathers" of the automobile are Gottlieb Daimler, the German who made the first successful gasoline engine, and Charles Goodyear, the American who discovered

the secret of vulcanized rubber. Without this engine to form the motive power and the pneumatic tire to give it four air cushions to run on, the automobile would never have progressed beyond the steam carriage stage. It is true that Charles Baldwin Selden, of Rochester, has been pictured as the "inventor of the modern automobile" because, as long ago as 1879, he applied for a patent on the idea of using a gasoline engine as motive power, securing this basic patent in 1895, but this, it must be admitted, forms a flimsy basis for such a pretentious claim.

The French apparently led all nations in the manufacture of motor vehicles, and in the early nineties their products began to make occasional appearances on American roads. The type of American who owned this imported machine was the same that owned steam yachts and a box at the opera. Hardly any new development has aroused greater hostility. It not only frightened horses, and so disturbed the popular traffic of the time, but its speed, its glamour, its arrogance, and the haughty behavior of its proprietor, had apparently transformed it into a new badge of social cleavage. It thus immediately took its place as a new gewgaw of the rich; that it had any other purpose to

serve had occurred to few people. Yet the French and English machines created an entirely different reaction in the mind of an imaginative mechanic in Detroit. Probably American annals contain no finer story than that of this simple American workman. Yet from the beginning it seemed inevitable that Henry Ford should play this appointed part in the world. Born in Michigan in 1863, the son of an English farmer who had emigrated to Michigan and a Dutch mother, Ford had always demonstrated an interest in things far removed from his farm. Only mechanical devices interested him. He liked getting in the crops, because McCormick harvesters did most of the work; it was only the machinery of the dairy that held him enthralled. He developed destructive tendencies as a boy; he had to take everything to pieces. He horrified a rich playmate by resolving his new watch into its component parts — and promptly quieted him by putting it together again. “Every clock in the house shuddered when it saw me coming,” he recently said. He constructed a small working forge in his school-yard, and built a small steam engine that could make ten miles an hour. He spent his winter evenings reading mechanical and scientific journals; he cared little for

general literature, but machinery in any form was almost a pathological obsession. Some boys run away from the farm to join the circus or to go to sea; Henry Ford at the age of sixteen ran away to get a job in a machine shop. Here one anomaly immediately impressed him. No two machines were made exactly alike; each was regarded as a separate job. With his savings from his weekly wage of \$2.50, young Ford purchased a three dollar watch, and immediately dissected it. If several thousand of these watches could be made, each one exactly alike, they would cost only thirty-seven cents a piece. "Then," said Ford to himself, "everybody could have one." He had fairly elaborated his plans to start a factory on this basis when his father's illness called him back to the farm.

This was about 1880; Ford's next conspicuous appearance in Detroit was about 1892. This appearance was not only conspicuous; it was exceedingly noisy. Detroit now knew him as the pilot of a queer affair that whirled and lurched through her thoroughfares, making as much disturbance as a freight train. In reading his technical journals Ford had met many descriptions of horseless carriages; the consequence was that he had again broken away from the farm, taken a job

at \$45 a month in a Detroit machine shop, and devoted his evenings to the production of a gasoline engine. His young wife was exceedingly concerned about his health; the neighbors' snap judgment was that he was insane. Only two other Americans, Charles B. Duryea and Ellwood Haynes, were attempting to construct an automobile at that time. Long before Ford was ready with his machine, others had begun to appear. Duryea turned out his first one in 1892; and foreign makes began to appear in considerable numbers. But the Detroit mechanic had a more comprehensive inspiration. He was not working to make one of the finely upholstered and beautifully painted vehicles that came from overseas. "Anything that isn't good for everybody is no good at all," he said. Precisely as it was Vail's ambition to make every American a user of the telephone and McCormick's to make every farmer a user of his harvester, so it was Ford's determination that every family should have an automobile. He was apparently the only man in those times who saw that this new machine was not primarily a luxury but a convenience. Yet all manufacturers, here and in Europe, laughed at his idea. Why not give every poor man a Fifth Avenue house? Frenchmen and Englishmen

scouted the idea that any one could make a cheap automobile. Its machinery was particularly refined and called for the highest grade of steel; the clever Americans might use their labor-saving devices on many products, but only skillful hand work could turn out a motor car. European manufacturers regarded each car as a separate problem; they individualized its manufacture almost as scrupulously as a painter paints his portrait or a poet writes his poem. The result was that only a man with several thousand dollars could purchase one. But Henry Ford—and afterward other American makers—had quite a different conception.

Henry Ford's earliest banker was the proprietor of a quick-lunch wagon at which the inventor used to eat his midnight meal after his hard evening's work in the shed. "Coffee Jim," to whom Ford confided his hopes and aspirations on these occasions, was the only man with available cash who had any faith in his ideas. Capital in more substantial form, however, came in about 1902. With money advanced by "Coffee Jim," Ford had built a machine which he entered in the Grosse Point races that year. It was a hideous-looking affair, but it ran like the wind and outdistanced all competitors. From that day Ford's career has been

an uninterrupted triumph. But he rejected the earliest offers of capital because the millionaires would not agree to his terms. They were looking for high prices and quick profits, while Ford's plans were for low prices, large sales, and use of profits to extend the business and reduce the cost of his machine. Henry Ford's greatness as a manufacturer consists in the tenacity with which he has clung to this conception. Contrary to general belief in the automobile industry he maintained that a high sale price was not necessary for large profits; indeed he declared that the lower the price, the larger the net earnings would be. Nor did he believe that low wages meant prosperity. The most efficient labor, no matter what the nominal cost might be, was the most economical. The secret of success was the rapid production of a serviceable article in large quantities. When Ford first talked of turning out 10,000 automobiles a year, his associates asked him where he was going to sell them. Ford's answer was that that was no problem at all; the machines would sell themselves. He called attention to the fact that there were millions of people in this country whose incomes exceeded \$1800 a year; all in that class would become prospective purchasers of a low-priced auto-

mobile. There were 6,000,000 farmers; what more receptive market could one ask? His only problem was the technical one — how to produce his machine in sufficient quantities.

The bicycle business in this country had passed through a similar experience. When first placed on the market bicycles were expensive; it took \$100 or \$150 to buy one. In a few years, however, an excellent machine was selling for \$25 or \$30. What explained this drop in price? The answer is that the manufacturers learned to standardize their product. Bicycle factories became not so much places where the articles were manufactured as assembling rooms for putting them together. The several parts were made in different places, each establishment specializing in a particular part; they were then shipped to centers where they were transformed into completed machines. The result was that the United States, despite the high wages paid here, led the world in bicycle making and flooded all countries with this utilitarian article. Our great locomotive factories had developed on similar lines. Europeans had always marveled that Americans could build these costly articles so cheaply that they could undersell European makers. When they obtained a glimpse of an

American locomotive factory, the reason became plain. In Europe each locomotive was a separate problem; no two, even in the same shop, were exactly alike. But here locomotives are built in parts, all duplicates of one another; the parts are then sent by machinery to assembling rooms and rapidly put together. American harvesting machines are built in the same way; whenever a farmer loses a part, he can go to the country store and buy its duplicate, for the parts of the same machine do not vary to the thousandth of an inch. The same principle applies to hundreds of other articles.

Thus Henry Ford did not invent standardization; he merely applied this great American idea to a product to which, because of the delicate labor required, it seemed at first unadapted. He soon found that it was cheaper to ship the parts of ten cars to a central point than to ship ten completed cars. There would therefore be large savings in making his parts in particular factories and shipping them to assembling establishments. In this way the completed cars would always be near their markets. Large production would mean that he could purchase his raw materials at very low prices; high wages meant that he could get the efficient

labor which was demanded by his rapid fire method of campaign. It was necessary to plan the making of every part to the minutest detail, to have each part machined to its exact size, and to have every screw, bolt, and bar precisely interchangeable. About the year 1907 the Ford factory was systematized on this basis. In that twelvemonth it produced 10,000 machines, each one the absolute counterpart of the other 9999. American manufacturers until then had been content with a few hundred a year! From that date the Ford production has rapidly increased; until, in 1916, there were nearly 4,000,000 automobiles in the United States — more than in all the rest of the world put together — of which one-sixth were the output of the Ford factories. Many other American manufacturers followed the Ford plan, with the result that American automobiles are duplicating the story of American bicycles; because of their cheapness and serviceability, they are rapidly dominating the markets of the world. In the Great War American machines have surpassed all in the work done under particularly exacting circumstances.

A glimpse of a Ford assembling room — and we can see the same process in other American factories — makes clear the reasons for this success.

In these rooms no fitting is done; the fragments of automobiles come in automatically and are simply bolted together. First of all the units are assembled in their several departments. The rear axles, the front axles, the frames, the radiators, and the motors are all put together with the same precision and exactness that marks the operation of the completed car. Thus the wheels come from one part of the factory and are rolled on an inclined plane to a particular spot. The tires are propelled by some mysterious force to the same spot; as the two elements coincide, workmen quickly put them together. In a long room the bodies are slowly advanced on moving platforms at the rate of about a foot per minute. At the side stand groups of men, each prepared to do his bit, their materials being delivered at convenient points by chutes. As the tops pass by these men quickly bolt them into place, and the completed body is sent to a place where it awaits the chassis. This important section, comprising all the machinery, starts at one end of a moving platform as a front and rear axle bolted together with the frame. As this slowly advances, it passes under a bridge containing a gasoline tank, which is quickly adjusted. Farther on the motor is swung over by a small hoist

and lowered into position on the frame. Presently the dash slides down and is placed in position behind the motor. As the rapidly accumulating mechanism passes on, different workmen adjust the mufflers, exhaust pipes, the radiator, and the wheels which, as already indicated, arrive on the scene completely tired. Then a workman seats himself on the gasoline tank, which contains a small quantity of its indispensable fuel, starts the engine, and the thing moves out the door under its own power. It stops for a moment outside; the completed body drops down from the second floor, and a few bolts quickly put it securely in place. The workman drives the now finished Ford to a loading platform, it is stored away in a box car, and is started on its way to market. At the present time about 2000 cars are daily turned out in this fashion. The nation demands them at a more rapid rate than they can be made.

Herein we have what is probably America's greatest manufacturing exploit. And this democratization of the automobile comprises more than the acme of efficiency in the manufacturing art. The career of Henry Ford has a symbolic significance as well. It may be taken as signaling the new ideals that have gained the upper hand in

American industry. We began this review of American business with Cornelius Vanderbilt as the typical figure. It is a happy augury that it closes with Henry Ford in the foreground. Vanderbilt, valuable as were many of his achievements, represented that spirit of egotism that was rampant for the larger part of the fifty years following the war. He was always seeking his own advantage, and he never regarded the public interest as anything worth a moment's consideration. With Ford, however, the spirit of service has been the predominating motive. His earnings have been immeasurably greater than Vanderbilt's; his income for two years amounts to nearly Vanderbilt's total fortune at his death; but the piling up of riches has been by no means his exclusive purpose. He has recognized that his workmen are his partners and has liberally shared with them his increasing profits. His money is not the product of speculation; Ford is a stranger to Wall Street and has built his business independently of the great banking interest. He has enjoyed no monopoly, as have the Rockefellers; there are more than three hundred makers of automobiles in the United States alone. He has spurned all solicitations to join combinations. Far from asking tariff favors

he has entered European markets and undersold English, French, and German makers on their own ground. Instead of taking advantage of a great public demand to increase his prices, Ford has continuously lowered them. Though his idealism may have led him into an occasional personal absurdity, as a business man he may be taken as the full flower of American manufacturing genius. Possibly America, as a consequence of universal war, is advancing to a higher state of industrial organization; but an economic system is not entirely evil that produces such an industry as that which has made the automobile the servant of millions of Americans.

BIBLIOGRAPHICAL NOTE

THE materials are abundant for the history of American industry in the last fifty years. They exist largely in the form of official documents. Any one ambitious of studying this subject in great detail should consult, first of all, the catalogs issued by that very valuable institution, the Government Printing Office. The Bureau of Corporations has published elaborate reports on such industries as petroleum (Standard Oil Company), beef, tobacco, steel, and harvesting machinery, which are indispensable in studying these great basic enterprises. The American habit of legislative investigation and trust-fighting in the courts, whatever its public value may have been, has at least had the result of piling up mountains of material for the historian of American industry. For one single corporation, the Standard Oil Company, a great library of such literature exists. The nearly twenty volumes of testimony, exhibits, and briefs assembled in the course of the Federal suit which led to its dissolution is the ultimate source of material on America's greatest trust. As most of our other great corporations — the Steel Trust, the Harvester Company, the Tobacco Company, and the like — have passed through similar ordeals, all the information the student could ask concerning them exists in the same form. The archives of such bodies as the Interstate Commerce

Commission and Public Utility Commissions of the States are also bulging with documentary evidence. Thus all the material contained in this volume — and much more — concerning the New York traction situation will be found in the investigation conducted in 1907 by the Public Service Commission of New York, Second District.

American business has also developed a great talent for publicity. Nearly all our big corporations have assembled much material about their own history, all of which is public property. Thus the American Telephone and Telegraph Company can furnish detailed information on every phase of its business and history. Indeed, one's respect for the achievements of American industry is increased by the praiseworthy curiosity which it displays about its own past and the readiness with which it makes such material accessible to the public. Despite the abundance of data, there is not a great amount of popular writing on these subjects that has much fascination as literature or much value as history. The only book that is really important is Miss Ida M. Tarbell's *History of the Standard Oil Company*, 2 vols. (new edition 1911). Of other popular volumes the present writer has found most useful Herbert N. Casson's *Romance of Steel* (1907), *History of the Telephone* (1910), and *Cyrus Hall McCormick: His Life and Work* (1909); J. H. Bridge's *Inside History of the Carnegie Steel Company* (1903); *Henry Ford's Own Story* as told to Rose Wildes Lane (1917).

For Chapter V, the author has drawn from articles contributed by him in 1907-8 to *McClure's Magazine* on *Great American Fortunes and their Making*; and for Chapter IV, from an article contributed to the same magazine in 1914, on *Telephones for the Millions*.

INDEX

- Acme Oil Company, 37
 Agricultural machinery, 149-69
 Alabama, steel in, 77
 American Bell Telephone Company, 114-15; *see also* American Telephone and Telegraph Company, Bell Company
 American Bridge Company, 81
 American Speaking Telephone Company, 111
 American Steel and Wire Company, 79, 81
 American Sugar Refining Company, 170
 American Telephone and Telegraph Company, upright business methods, 92-93; takes over American Bell Company, 115; growth of, 115; bibliography, 190; *see also* American Bell Telephone Company, Bell Company
 American Transfer Company, 38
 Andrews, Samuel, associate of Rockefeller, 33, 35
 Appleby, J. F., inventor of twine binder, 154, 160
 Archbold, J. D., President of Acme Oil Company, 37; associate of Rockefeller, 42
 Armour and Company, 170
 Aspinwall, William, 12
 Astor, W. B., 10
 Automobiles, 171 *et seq.*
 Barnum, P. T., 12
 Barrett, J. P., invents telephone cable, 103
 Beach, M. Y., *Wealthy Men of New York*, 10, 11
 Bell, A. G., inventor of telephone, 88; life, 93-94; works on "harmonic telegraph," 94-97; invention of telephone, 97-98; lectures to finance scheme, 106; returns to teaching deaf-mutes, 113; later activities, 113
 Bell, Mrs. A. G., 92
 Bell Company, Vail as General Manager, 107-11; trouble with Western Union, 111-13; buys Western Union Telephone System, 113; *see also* American Bell Telephone Company, American Telephone and Telegraph Company
 Bennett, Arnold, quoted, 86-87
 Berkman attacks Frick, 72
 Berliner, Emile, invents a telephone transmitter, 101
 Bessemer, Henry, developed steel manufacture, 61-62
 Birmingham (Ala.), steel manufacture in, 77-78
 Bishop, Japhet, 12
 Bismarck, Prince, quoted, 153-154
 Bissell, G. H., interest in refining of petroleum, 28-29
 Blake, Francis, invents a telephone transmitter, 101
 Boston, telephones in, 89
 Brewster, Benjamin, associate of Rockefeller, 41
 Broadway railroad franchise, 136-39

- Brooklyn Rapid Transit, 146
- Calhoun, Patrick, 124
- Carnegie, Andrew, a maker of American Steel Age, 59; quoted, 60; genius of, 66-69; retires from business life, 80; sells interests to Morgan, 84
- Carnegie Steel Company, 76, 79
- Carty, J. J., improves telephone, 93, 102-03
- Chicago, steel production in, 77; telephones in, 89; street railway corruption, 125-26, 142-143, 144-45; McCormick establishes factory at, 162
- Choate, J. H., 130
- City government, corruption of, 123-24; *see also* Chicago, New York City
- Civil War, effect on industrial development, 13 *et seq.*
- Cleveland, Grover, 131
- Cleveland, oil refining center, 36; steel production in, 77
- Clifford, George, conducts case for Western Union against Bell Company, 112
- Coal, importation in 1865, 4; deposits in U. S., 4-5
- Coggeswell, W. L., 12
- Coleman, Pittsburgh steel magnate, 66
- Colorado Fuel and Iron Company, 57, 77
- Columbia Conduit Company, 39
- Competition in 1865, 7-9
- Conkling, Roscoe, counsel for legislative investigation of Broadway franchise, 136, 138
- Conneaut (O.), terminus for ore shipping, 75; Carnegie builds steel plant at, 82
- Connellsville coal, 71-72
- Cooper, Peter, 12
- Copper importation in 1865, 4
- Cudahy Packing Company, 170
- Daimler, Gottlieb, inventor of gasoline engine, 174
- Deering, William, 159-60, 168
- Deering Company, William, 167
- Dolan helps combine public utilities, 121
- Doolittle, T. B., invents hard-drawn copper wire, 102
- Drake, E. L., drills first oil wells, 29-30
- Duryea, C. B., constructs automobile, 178
- Edison, T. A., devises telephone transmitter, 101, 112; invents incandescent light, 121
- Elkins, W. L., helps combine public utilities, 121; in Philadelphia, 123, 129, 134; connection with Broadway franchise, 138; in Chicago, 142, 143, 145
- Emery, Lewis, Jr., builds pipe lines, 55
- Empire Transportation Company, 39
- Everett, P. M., discovers iron in Minn., 63-64
- Federal Steel Company, 81
- Flagler, H. M., associate of Rockefeller, 35, 42
- Flower, R. P., Governor of N. Y., 123-24
- Ford, Henry, wealth, 172; life and achievements, 176 *et seq.*
- Forests, beginning of exploitation, 3
- Frick, H. C., a maker of American Steel Age, 59, 66; personal characteristics, 70-71; "coke king" of Connellsville, 71-72; receipts in 1900, 80
- Fullgraff, "boodle alderman" in New York street railway corruption, 137
- Gates, J. W., introduces wire fencing, 78-79; discusses steel situation with Morgan, 84

- Glessner, J. J., establishes factory for self-binders, 167, 168
- Goodyear, Charles, discovers secret of vulcanized rubber, 174-75
- Gould, G. J., 83
- Gray, Elisha, perfects "harmonic telegraph," 95; invents telephone, 96-97
- Gulf Refining Company, 56
- Haggerty, John, 12
- Hanna, Mark, 123
- Harmony, Peter, 12
- Haupt, General Herman, builds pipe line for Tidewater Company, 39
- Haynes, Ellwood, constructs automobile, 178
- Homestead strikes, 72, 73
- Hostetter builds pipe line for Columbia Conduit Company, 39
- Hubbard, G. G., interest in Bell's experiments, 94; refuses at first to finance telephone, 97; places Vail as General Manager of Bell Company, 106-07; later life, 113
- Hudson River Railroad, 23, 24
- Humming, Rev. Henry, suggests improvements in telephone, 101
- Immigration after Civil War, 14
- Industrial combinations, Western Union Telegraph Company, 9; railroads, 9, 23-24; Standard Oil Company, 25, 36, 52-54; United States Steel Corporation, 84-85; International Harvester Company, 153, 167-169; *see also* names of corporations
- International Harvester Company, 153, 167-69
- Interstate Commerce Act (1887), 48
- Iron, in U. S., 5; in Minn., 63-64
- Jennings, Oliver, associate of Rockefeller, 41
- Johnstown (Pa.), steel production at, 77
- Joliet (Ill.), steel production at, 77
- Jones, Captain Bill, early maker of steel, 66, 68
- Jones, W. H., manufacturer of self-binders, 167, 168
- Kansas City, telephones in, 89
- Kelly, William, discovers "Bessemer process" of making steel, 61, 62
- Kemble, W. H., plays part in public utilities corruption, 125, 138
- Kier, S. M., exploits petroleum as medicine, 27-28
- Kloman, Pittsburgh steel magnate, 66
- Land, beginning of exploitation, 3
- Law, George, 12
- Lenox, James, 11
- London *Times*, comments on invention of telephone, 87; ridicules McCormick harvester, 166
- Lorain (O.), steel production in, 77
- Los Angeles, telephones in, 89
- McCandless, Pittsburgh steel magnate, 66
- McCormick, C. H., invents reaper, 149, 150; life and achievement, 154-57; as a business man, 160-64; harvester exhibited at London Exposition (1851), 166; death (1884), 167; growth of business, 169
- McCormick, Robert, father of C. H., 155-56
- McKay sewing machine, 16
- McQuade, A. J., 137

- Manufactures, in 1865, 5-7;
effect of Civil War on, 16-17;
in early 20th century, 171
- Marsh, C. W., invents improvement to reaper, 154, 158
- Mercer, J. P., City Treasurer in Philadelphia, 127
- Mesaba iron ore range, 57
- Metropolitan Street Railway Company, 139 *et seq.*
- Metropolitan Traction Company, 139, 141 (note)
- Minnesota, iron fields of, 63-65
- Monopolies, *see* Industrial combinations
- Morgan, J. P., 81, 84, 168
- Morris and Company, 170
- Municipal government, *see* City government
- National Packing Company, 170
- National Tube Company, 81, 82
- New York Central Railroad, under Vanderbilt, 23-24; rebates granted by, 45-48
- New York City, telephones in, 88-89; street railways, 119; street railway corruption, 135-147
- Northcliffe, Lord, telephone demonstration, 86
- Oil, first "oil gusher," 4; "Oil Creek," 26-27; used as medicine, 27-28; Bissell's project, 28-29; Silliman's report, 28; "Drake's folly," 29; rush to oil-fields, 30; commercial importance, 31; in Middle West and West, 56; *see also* Standard Oil Company
- Osborne, D. M., manufactures arm machinery, 167
- Page, Dr. C. C., article on theory of sound, 96
- Pennsylvania, oil in, 26 *et seq.*
- Pennsylvania Railroad, rebates granted by, 44-46; monopoly in and out of Pittsburgh, 83
- Perkins, G. W., 81, 168
- Petroleum, *see* Oil
- Philadelphia, telephones in, 89; public utilities, 121 *et seq.*
- Phipps, Henry, associate of Carnegie, 59, 66, 69-70; receipts in 1900, 80
- Pittsburgh as steel center, 74-75
- Public utilities, 119 *et seq.*
- Public Utility Commissions, 148
- Pupin, M. I., invents "Pupin coil," 93, 103-05
- Pure Oil Company, 55, 56
- Railroads, of Civil War days, 2; combinations, 9, 23-24; *see also* Vanderbilt
- Rebates, to Standard Oil Company, 43-44, 48; to South Improvement Company, 45-46; to Carnegie, 76
- Reis, Philip, telephone experiments by, 96
- Rockefeller, J. D., 31 *et seq.*
- Rogers, H. H., associate of Rockefeller, 42
- Rural free delivery, 90
- Ryan, T. F., effects combinations of public utilities, 121; in Tammany Hall, 123; buys Chicago railway system, 126; life and character, 132-34; connection with New York street railways, 137, 138
- Salt manufacture, 27-28
- Sanders, Thomas, patron of Bell, 94, 95; refuses at first to finance telephone, 97; withdraws from telephone company, 113
- Schwab, C. M., 80; associate of Carnegie, 59, 66; personal characteristics, 70-71; reorganizes Homestead Works, 72-73; made President of Carnegie Company, 73; to be manager

- Schwab, C. M.—*Continued*
 at Conneaut, 83; discusses steel situation with Morgan, 83-84
- Schwarzschild and Sulzberger, 170
- Scott, T. A., President of Pennsylvania Railroad, 44, 49, 66; makes Carnegie private secretary, 67; partner of Carnegie, 76
- Scribner, C. E., inventor of multiple switchboard, 93, 103
- Selden, C. B., "inventor of the modern automobile," 175
- Seward, W. H., quoted, 165
- Sharp, Jacob, connection with New York street railway corruption, 135-36
- Shinn, Pittsburgh steel magnate, 66
- Shipbuilding, 3
- Shoe manufacture, 6, 16, 171
- Silliman, Benjamin, Jr., report on petroleum analysis, 28
- South Improvement Company, 44-47
- Sprague, F. J., constructs urban trolley, 121
- Standard Oil Company, evolution typical of economic change, 3; of Ohio, in 1877, 25; incorporated (1870), 36; development, 36 *et seq.*; methods of marketing oil, 50-51; organization, 52-53; Standard Oil Trust, 53; of N. J., 53-54; combination dissolved, 54; financial power of, 57; bibliography, 189, 190; *see also* Rockefeller
- Steel, increased use of, 58-59; growth of industry in America, 60-61, 75-78; reasons for success in America, 73-74; bibliography, 189, 190; *see also* Carnegie
- Stetson, F. L., invents "holding company," 139
- Stewart, A. T., 12
- Stewart, Pittsburgh steel magnate, 66
- Stone, Amasa, associate of Rockefeller, 41
- Street railways, *see* Chicago, New York City
- Sumner, W. G., 130
- Swift and Company, 170
- Tammany Hall, 123, 131, 133
- Telephone, 86 *et seq.*; bibliography, 190
- Texas Refining Company, 56
- Thompson, J. E., 66
- Tidewater Company, 40
- Tilden, S. J., 130
- Tobacco Trust, 170-71, 189
- Transportation, effect of Civil War on, 15
- Trusts, *see* Industrial combinations
- Tweed, W. M., 130
- United Pipe Line Company, 39
- United States, economic conditions in 1865, 1 *et seq.*
- United States Steel Corporation, 3, 84-85
- Vail, Stephen, 107
- Vail, T. N., General Manager of Bell Company, 107 *et seq.*
- Vanderbilt, Cornelius, 11, 18-24, 49, 186
- Vanderbilt, W. H., quoted, 41-42
- Vandervoort, Pittsburgh steel magnate, 66
- Van Syckel, Samuel, discovers use of oil pipes, 30
- Watson, T. A., associate of Bell, 97, 98, 106, 113-14
- Wealth in 1855, distribution of, 10-11; sources of, 11-12
- Western Electric Manufacturing Company, 114
- Western Union Telegraph Company, 9, 88, 101, 111-14

- Western Union Telephone Company, 113
- White, Chief Justice E. D., renders Standard Oil decision, 54
- Whitney, Eli, 154
- Whitney, Stephen, 10-11
- Whitney, W. C., helps combine public utilities, 121; in Tammany Hall, 123; buys Chicago railway system, 126; life and activities, 130-32; connection with public utilities corruption, 134, 137, 138, 139, 146-47
- Widener, P. A. B., helps combine public utilities, 121; in Philadelphia, 123, 134; personal characteristics and life, 127-129; part in New York street railway corruption, 138; in Chicago, 142, 143, 145
- Withington, C. B., inventor of self-binder, 154, 159
- Yerkes, C. T., helps combine public utilities, 121; in Chicago, 123, 125-26, 134, 143, 144-145; operations in London, 126
- Youngstown (O.), steel production at, 77

11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
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27
28
29
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